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EXPERIMENTS WITH CROPS AND STOC

CONDUCTED BY

THE AGRICULTURAL DEPARTMENT,

OF THE

Durham College of Science, Newcastle-upon-Ty

DURING SEASON 1900.

Ninth Annual Report,

COMPILED BY

T. H. MIDDLETON, M.Sc.,
Professor of Agriculture and Rural Economy.

LONDON AND NEWCASTLE-UPON-TYNE:
ANDREW REID AND COMPANY, LIMITED, PRINTERS AND PUBLISHERS.

1901.

PREFACE.

The experiments described in this Report have been carried out (*a*) at local stations in the three Northern Counties, which have been placed at the disposal of the College by their owners, or occupiers; (*b*) on the Northumberland County Demonstration Farm, Cockle Park, Morpeth; (*c*) at the Cumberland County Farm School, Newton Rigg, Penrith.

The local experiments are of two kinds, viz.: Those which last for one season only—on Swedes, Potatoes, etc.; and those which continue for a series of years—Rotation and Meadow Hay experiments. The manures for these experiments are all sent out from the College and delivered free of cost to the farmer who provides the land. Members of the Agricultural Staff measure off the plots, attend when necessary to see the manures applied, inspect the growing crops, and in almost all cases see the produce weighed. Mr. Lawrence of Newton Rigg co-operates with the College representatives in the case of stations located in Cumberland. The details of the field work and of the feeding experiments at Cockle Park are carried out by the Farm Manager, the scientific direction being supplied by the College. For the experiments at Newton Rigg, Mr. Lawrence is responsible.

The analyses which the experiments involve are made in the College Laboratory by Mr. Collins.

During season 1900, the field experiments with which members of the College Agricultural Staff were directly concerned numbered about 74, distributed as follows:—

	Number of Centres.	Number of Plots.	Area of land under experiment. Acres.
Temporary local stations	36	545	28
Rotation and Hay Stations	18	348	42
Cockle Park Farm (about)	20	350	120
	74	1243	190

The leading object in these numerous field trials is to obtain precise information respecting the manurial condition of soils in certain localities, the effects of manures on the yield of crop, and their influence on quality and feeding properties.

All the permanent and nearly all the temporary stations were inspected, and when, for any reason, the results of the experiments were likely to mislead, the figures relating to them were excluded from the "averages" or have been omitted.

The Appendix contains Tables giving detailed figures for all the experiments reported upon. A summary of the leading facts has been given at the end of many of the sections.

Any careful reader will remark inconsistencies in the figures. The conditions under which field experiments are carried out make it impossible that the results should be uniform, but each result *correctly represents the effects of certain conditions, and is of value if rightly interpreted.* Care is necessary in drawing conclusions, and averages of small groups of results may often prove deceptive. It is preferable in most instances to consider each result by itself. With the object of helping the reader to do this, diagrams have been prepared to illustrate the results of certain of the experiments.

For purposes of calculation, the manures used have been valued at the following rates :—

	Per Ton.		
Nitrate of Soda (15·5 % Nitrogen)	£9	0	0
Sulphate of Ammonia (20·6 % Nitrogen)	12	0	0
Superphosphate (28 % Soluble Phosphate)	3	0	0
Basic Slag (37 % Insoluble Phosphate)	2	5	0
Bone Meal (52 % Insoluble Phosphate and 3½ % Nitrogen)	5	10	0
Dissolved Bones (22 % Soluble Phosphate, 12 % Insoluble Phosphate, 2½ % Nitrogen)	5	0	0
Fish Meal (11 % Phosphate, 8 % Nitrogen)	6	10	0
Muriate of Potash (50 % Potash)	9	10	0
Sulphate of Potash (30 % Potash)	5	10	0
Kainit (12 % Potash)	2	5	0

The percentages given indicate the quality of the manure upon which the price has been based, the actual composition varied in different cases; tables of analyses will be found upon pp. 232 and 233.

T. H. MIDDLETON.

THE DURHAM COLLEGE OF SCIENCE,
NEWCASTLE-UPON-TYNE,
April, 1901.

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EXPERIMENTS ON THE MANURING OF SWEDES.

Experiments on the manuring of this Root crop were made at the thirteen centres in the County of Durham, named below:—

No.	Farm.	Occupier.	Remar s.
1	East House Farm, Seaham Harbour	Mr. J. D. Dunn ...	Sutton's Purple-top Swedes on clay soil, after lea oats.
2	Hesledon West Farm, South Hetton	„ H. A. J. Atkinson	Perfection Swedes on light loam, after lea oats.
3	Flinton Hill, Sunderland	„ R. Maclaren ...	Kangaroo Swedes on light loam, after oats after wheat.
4	Offerton Hall, Sunderland	„ J. Maclaren ...	Best of All Swedes on medium loam, after oats.
5	South Farm, East Boldon	„ G. F. Taylor ...	Kangaroo Swedes on stony loamy soil, after lea oats.
6	Skerningham, Darlington	„ R. Johnson ...	Perfection Swedes on heavy soil, after lea oats. Crop had to be re-sown.
7	Summerhouse, Piercebridge	„ G. Stephenson ...	Best of All Swedes on light loam, after lea wheat.
8	Little Chilton, Ferryhill	„ R. Wilkinson ...	Seed home-grown. Soil light and open; in good condition; previous crops, wheat after potatoes after turnips, both of latter dunged.
9	Brandon House, West Cornforth	„ J. J Furneis ...	Mr. Cleasby's Seed on light soil, after wheat after potatoes.
10	Earls House, Durham	Managers of County Industrial School	XL All Swedes on clay soil, after a cereal crop.
11	Broomside House, Durham	Mr. R. H. Cleasby ...	Crop much injured by Finger-and-toe, and not weighed.
12	White House, Lanchester	„ U. A. Ritson ...	Crop brairded badly and was re-sown; not weighed.
13	Witton Hall, Witton Gilbert	„ T. R. Holmes ...	Crop irregular, and injured by Finger-and-toe; not weighed.

The objects of the experiments were:—

1. To test the soils on which they were carried out.

2. To ascertain the effects of employing artificial manures with Dung.
3. To test various artificial mixtures when used with and without Dung.

At each centre there were 20 plots, the plots were rather more than 1-27th of an acre in size, and consisted of six 28-inch drills, 39 yards long, or six 27-inch drills 40½ yards long. In every case the four central drills, measuring exactly 1-40th acre, were weighed. This size of plot is very convenient for manurial trials on the root crop, the small size enables the experimenter to secure uniform soil conditions, and this in practice more than counter-balances the disadvantage involved in employing so large a multiplier as "40" in converting the results "per plot" into results "per acre."

The crops at all the centres were inspected; in two cases Finger-and-toe had played such havoc with the swedes that it was decided not to weigh them, and in a third case where the swedes brairded badly and were replaced by yellow turnips, the crop was not weighed. The crops were weighed at ten centres and the detailed results, together with the manures employed, will be found in Table I. At West Cornforth, Plots 1, 9, 16 and 17, and at Skerningham several of the plots suffered from inequalities in the soil, and so the weights of the swedes at these stations have been excluded from the averages. At Hesledon West Farm, Plots 16 and 17 were on stiffer land than the rest and the roots suffered considerably, to the extent probably of 3 and 6 tons respectively; but as the other plots were satisfactory the figures obtained from this station have been included in the averages.

The results may now be discussed under the heads already mentioned, and first:—

What does the land require?—

In this case the question was narrowed down, and the answer which the farms tested were asked to supply was "Is Nitrogen or Phosphoric Acid or Potash the manurial ingredient most necessary to the turnip crop growing on your soil"? The turnip crop is of all common crops the best adapted for soil testing, it is particularly sensitive to a lack of Phosphates, and is also readily affected by a deficiency of Nitrogen and Potash. From the character of the root crop on land tested in the way to be presently indicated, a farmer may not only gain information respecting the requirements of the crop itself, but information that will assist him in the treatment of his other crops.

Six of the twenty swede plots were more specially devoted to a soil test. The first in order—No. 11 of the experiment—was the unmanured plot; it forms the standard at one end of the series; Plot 13, with an artificial dressing of 1 cwt. Nitrate of Soda, ¾ cwt. Sulphate of Ammonia, 7 cwt. Superphosphate, and 4 cwt. Kainit forms the standard at the other end,* and Plots 19, 20, and 18 show respectively the results of omitting the nitrogenous, the phosphatic and the potash manures from this general mixture. Plot 12 which had half the general dressing given to Plot 13 is included for comparison with both the complete and the incomplete mixtures.

The average results obtained from eight of the thirteen stations are shown in the following statement.

Plot.	Per Acre.				
	Manuring.	Cost of Manure.	Average Yield.	Increase due to Manure.	Profit or Loss.†(–)
		s. d.	T. cwt.	T. cwt.	s. d.
11	**No Manure**	—	6 0	—	—
13	7 cwt. Super., 1 cwt. Nitrate of Soda. ¾ cwt. Sulphate of Ammonia and 4 cwt. Kainit (**Complete Manure**)	48 0	18 2	12 2	48 10
12	**Half** the dressing of Plot 13 ...	24 0	15 4¼	9 4¼	49 8
19	Same as Plot 13, but no **Nitrogen** ...	30 0	14 6¾	8 6¾	36 8
20	Do. but no **Super** ...	27 0	7 10¼	1 10¼	-14 11
18	Do. but no **Kainit** ...	39 0	15 13¼	9 13¼	38 4

* 35 lbs. Nitrogen, 100 lbs. Phosphoric Acid (P_2O_5), and 50 lbs. Potash per acre.

† Swedes, 8s. per ton.

Comparing the unmanured with the manured plots, it will be seen that with swedes at 8s. per ton the dressing which leaves most immediate profit is the smaller of the two artificial mixtures, but in view of the benefit to the future crops that is implied by the difference between a root crop of 18 and 15 tons per acre (apart from the food and manure value of the swedes themselves) there can be no question that the larger dressing is the better of the two. One interesting point to be noted regarding the returns from Plot 12 is that it is *on the average* more profitable to cheapen a mixture by reducing all round, than by omitting one of the constituents. The crop on Plot 18 was better, and on Plot 19 not much worse, than on Plot 12, but in neither case has the artificial mixture been as profitable. In only one case has the artificial manure proved unprofitable, viz., on Plot 20, where Superphosphate was omitted. The experiment clearly proves that on the average of these Durham farms, a Phosphate is much the most important element in a turnip manure. For this result everyone who studies "average results" will be prepared. The same average result would probably be got from any other group of eight farms in the kingdom. But though "average results" are very useful to the student of Agriculture they may form most unsuitable reading for the practical farmer, whose duty is to make himself intimately acquainted with the particular needs of his own farm. If the reader will turn to the details given in Table I. he will find that three times in ten cases the "average result" did not hold good. At West Cornforth and at Little Chilton, Nitrogen, and at Earl's House, Potash, was the most necessary constituent of the manure (as it also was at Cockle Park where the same experiment was made). Further, it will be noticed that in those cases where Phosphates proved to be most necessary, the absence of 7 cwt. of Superphosphate from the general mixture produced very different effects. At Hesledon West Farm the crop was an absolute failure; small crops were grown at Flinton Hall, East Boldon and Summerhouse; but there was a fair crop at Offerton Hall. It may be pointed out that those farms which show acute Phosphate-hunger lie on the Magnesian Limestone of the east of Durham, and that the two farms where Nitrogen-hunger was most marked are situated within four miles of each other in the Ferryhill district.

Does it pay to employ Artificial Manures with Dung?—

In numerous experiments made in the counties of Northumberland and Durham, in the years 1892-1895, it was shown that "so far as the root crop is concerned, a dressing of about 12 tons per acre of good Dung will produce nearly a full crop, and although the crop may be increased to a slight extent by the addition of Artificials, such increase will not cover the outlay thus incurred. The Artificials will, however, increase to some extent the succeeding crop of cereals, and it is probable that their cost may ultimately be recovered—in some cases a profit may even be got—but it would appear that their action when used along with Dung is much less than has usually been assumed." (Report for 1895, p. 118.)

This conclusion, which was very clearly warranted by the experiments made, is at variance with a common belief, and, last season being particularly favourable for the purpose, it was resolved to make a further test.

The following Table gives a statement of the result. Plot 10 received 12 tons of Dung per acre, and may be taken as a starting point. Plot 3 got 12 tons of Dung and in addition the same artificial mixture as Plot 12 (see details in the Table), Plots 9 and 8 had the same manuring except that the nitrogenous and potash manures were omitted in turn from the artificial mixture. Plots 1 and 2 got respectively 18 tons of Dung and 18 tons with the same artificial mixture as was used on Plot 3.

As already indicated the wet late spring of 1900 was particularly suitable for proving the direct value of a supplementary artificial dressing, yet Plot 3 shows that, on the average, if swedes are valued at 8s. per ton, the use of a general artificial manure has not been directly profitable. A more economical mixture containing Slag instead of Superphosphate was used on Plot 14, this mixture just repaid its cost. Matters have not been improved by omitting the nitrogenous or the potash manures from the artificial dressing; it would indeed seem that Nitrate and Sulphate were the most important ingredients of the mixture. The addition to Dung of 3½ cwt. Superphosphate and 2 cwt. of Kainit, costing 15s. has only increased the crop by 11 cwt. of swedes; the nitrogenous manures costing 9s. have further increased the yield by 2 tons per acre. This result indicates that if, for the sake of the subsequent crops, a farmer uses phosphatic and potash dressings with 12 tons of Dung for the swedes, it will often be advisable to use nitrogenous manures, for the sake of the direct profit.

Plot.	Per acre.				
	Manuring	Cost of Manure.	Average Yield.	Increase over Plot 10.	Loss.* (–) Compared with Plot 10.
		s. d.	T. cwt.	T. cwt.	s. d.
10	12 tons Dung	60 0	17 12¼	—	—
3	12 tons Dung with 3½ cwt. Super., ½ cwt. Nitrate of Soda, ⅜ cwt. Sulphate of Ammonia and 2 cwt. Kainit.	84 0	20 4¼	2 12	– 3 2
9	12 tons Dung with 3½ cwt. Super. and 2 cwt. Kainit.	75 0	18 3¾	0 11½	–10 5
8	12 tons Dung with 3½ cwt. Super., ½ cwt. Nitrate of Soda and ⅜ cwt. Sulphate of Ammonia.	79 6	19 6¾	1 14½	– 5 8
1	18 tons Dung	90 0	19 8¾	1 16½	–15 5
2	18 tons Dung with 3½ cwt. Super., ½ cwt. Nitrate of Soda, ⅜ cwt. Sulphate of Ammonia and 2 cwt. Kainit.	114 0	20 5	2 12¾	–32 11

* Swedes, 8s. per ton.

Referring to Table I. it will be seen that in this section of the experiment the averages nearly represent the results of each station. In almost all cases the effect of adding an artificial dressing to 12 tons of Dung was to increase the crop by from 2 to 5 tons per acre. Offerton Hall was an exception. Here the plots lay on a slope. Plot 10 was lower down than Plot 3 and may have had a slight advantage, though when the crop was inspected, no superiority in the soil was noticed. The view that Plot 10 was the better appears probable from the results of Plots 1 and 2. At one station (East House) the use of Kainit appears to have done harm, for where it has been omitted on Plots 8 and 18 the crop has been increased in both cases. The injury is probably due to the salt contained in Kainit. Previous experiments have shown that salt is frequently detrimental to the turnip crop especially in the presence of Dung. It is rarely that an application of 2 to 4 cwt. of Kainit will be found to exert any injurious influence on the root crop and it may be noted that in this case of supposed injury the soil was a thin clay on the Magnesian Limestone, and that it was very deficient in available Phosphates.

As a result of increasing the dressing of Dung from 12 to 18 tons, we have increased the crop of swedes by 36½ cwt. per acre. The increase is not a profitable one, for whereas the first dressing of 12 tons has resulted in 7s. 8d. worth of produce per ton of Dung used, the further application of 6 tons has produced crop worth only 2s. 4d. per ton of Dung. The only stations which differed widely from the average in the case of Plot 1 were Little Chilton, East House and West Cornforth. At the first named farm the larger dressing of Dung produced nearly six tons more crop than the smaller, but as Plot 1 at this station was a good deal better than Plot 2, which had 18 tons of Dung and Artificials in addition, the heavy crop may be regarded as accidental. At East House the heavier of the two dressings of Dung distinctly injured the crop. The injury was plainly visible when the growing crop was inspected, and, as the soil and adjacent crops were both uniform, it must be concluded that the poor crop on Plot 1 was due to some unfavourable action of the heavy dressing of Dung on the land. At West Cornforth the poor crop on Plot 1 was caused by the dry gravelly soil on which the plot was located through an oversight.

Plot 2 which got an artificial mixture in addition to 18 tons of Dung shows, as has often been shown before, that when the Dung supply is abundant, a dressing of Artificials has very little effect on the swede crop. The crops grown with 12 tons of Dung and Artificials on Plot 3 were on the average just as good as where 18 tons of Dung and Artificials were used, the only noteworthy exception was at Offerton Hall, the superiority of the heavier dressing here being well seen when the station was inspected.

Comparative values of Common Manures.—

The third subject with which this year's swede experiment deals, is the relative value of certain common manures, used both with and without Dung. The form which the trial took, and the results are given below. It may here be explained that each of the Plots 3 to 7 got the same quantity of Nitrogen, Phosphates and Potash, in various Artificials along with 12 tons of Dung, and that Plots 13 to 17 got double the Artificials of the corresponding Plots 3 to 7 but without Dung. Plots 3 and 13 may be taken as the standards with which to compare the other plots.

It will be noticed that not one of the plots mentioned in the following Table has produced a heavier crop than the standard Nos. 3 and 13. But, as Slag is considerably cheaper than Superphosphate and is almost as efficient, Plots 4 and 14 are the most profitable of the series. Bone Meal when used with Dung did fairly well as compared with equivalent amounts of Superphosphate, Nitrate and Sulphate, but in the absence of Dung, Bone Meal made a poor substitute for the more soluble manures. The dressing used on Plot 17 in which half the Phosphate came from Bones and half from Superphosphate did very well, and if the results at Hesledon West Farm (where the soil of Plot 17 was not satisfactory) were excluded this mixture of manures would have yielded over 18 tons per acre.

Fish Meal proved itself a quicker acting manure than Bone Meal, and Plot 16 was considerably ahead of Plot 15 at all the centres except West Cornforth and South Hetton (exceptions due to irregularities in the soil), but Fish Meal though an effective is an expensive manure and its use has not been profitable.

Plot.	Per Acre.								
	Manuring.	Cost of Manure.		Average Yield.		Increase or Decrease.*		Profit or Loss.* (−)	
		s.	d.	T.	cwt.	T.	cwt.	s.	d.
3	3¾ cwt. ***Super.***, ½ cwt. Nitrate of Soda, ⅜ cwt. Sulphate of Ammonia, and 2 cwt. Kainit, with 12 tons Dung.	84	0	20	4½	—		—	
13	Double ditto. Without Dung ...	48	0	18	2	—		—	
4	2½ cwt. ***Slag,*** ½ cwt. Nitrate of Soda, ⅜ cwt. Sulphate of Ammonia, 2 cwt. of Kainit, with Dung	79	0	20	0	−0	4¼	+3	4
14	Double ditto. Without Dung ..	38	0	17	10	−0	12	+5	2
5	2 cwt. **Bone *Meal,*** ¼ cwt. Nitrate of Soda, 3/16 cwt. Sulphate of Ammonia, and 2 cwt. Kainit, with Dung.	80	0	19	5	−0	19¼	−3	8
15	Double ditto. Without Dung ...	40	0	15	16¾	−2	5¼	−10	1
6	3 cwt. Super., 2 cwt. **Fish *Meal,*** 2 cwt. Kainit, with Dung	86	6	19	7¼	−0	17	−9	4
16	Double ditto. Without Dung ...	53	0	17	14¾	−0	7¼	−7	11
7	1 cwt. **Bone *Meal,*** 1¾ ***Super,*** ⅜ cwt. Nitrate of Soda. ¼ cwt. Sulphate of Ammonia, and 2 cwt. Kainit, with Dung.	82	0	19	18¼	−0	18	−5	2
17	Double ditto. Without Dung ...	44	0	17	1	−1	1	−4	5

* As compared with Plots 3 and 13.

The verdict of the average column as to the relative values of the different artificial mixtures is upheld by the results obtained at most of the centres, the only important exception being at Offerton Hall, where Superphosphate has done much better than Slag, the crops on Plots 13 and 14 being respectively 20¾ and 16¾ tons. At most of the stations Slag has been a remarkably efficient substitute for the more expensive Superphosphate. To take those centres for example where Phosphates have done most good we have the following interesting results:—

Plot.	Manuring.	Cost of Manures.		Seaham Harbour.	South Hetton.	Flinton Hill.	East Boldon.	Summerhouse, Piercebridge.	Average.
		Per Acre.							
		s.	d.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
20	1 cwt. Nitrate of Soda ¾ ,, Sulphate of Ammonia 4 cwt. Kainit ...	27	0	2	$\frac{1}{20}$	3½	5½	6	3⅖
13	Do., with 7 cwt. **Super.**	48	0	16	16¾	22¼	17	19½	18⅓
14	Do., with 5 cwt. **Slag**	38	0	14½	17	23½	16¾	20	18⅓
15	½ cwt. Nitrate of Soda ⅜ ,, Sulphate of Ammonia 4 cwt. Kainit ... 4 ,, **Bone Meal...**	40	0	10¾	16	22½	15½	18½	16⅗

The above figures show clearly that the turnip crop on these five farms (which without a phosphatic manure was a failure) *was able to utilise the insoluble Phosphate in Slag just as well as the soluble Phosphate in Superphosphate*; they further indicate that the insoluble Phosphate of Bone Meal is also readily available. The fact that the Bone Meal plot received not only its Phosphate, but half of its Nitrogen from an insoluble source accounts for the inferior crops on Plot 15. That this is so may be inferred from the crops of Plot 15 on

Little Chilton and East House, two farms on which the total absence of a nitrogenous manure was severely felt by the root crop.

Summary.—

1. All farmers should ascertain which of the leading ingredients of manure is most deficient in their soils. A trial made on the swede crop will often give this information, and further if taken in conjunction with the results of Rotation experiment, made in similar soils, will afford useful indications for the manuring of other crops.

2. A Phosphate is usually the most important ingredient in a manure for swedes; but the exceptions are numerous, and the necessity for Phosphates varies widely. Apparently soils lying on the Magnesian Limestone in East Durham are very poor in available Phosphates.

3. When 6⅜ cwt. of a general artificial manure, costing 24s. and compounded from Superphosphate, Kainit, Nitrate, and Sulphate, was used with 12 tons of Dung and the increase was valued at 8s. per ton, the added Artificials did not leave a direct profit, although the season was favourable to the action of artificial manures. When Slag was substituted for Superphosphate the increase in crop just paid for the artificial manure.

4. Taking the results of Rotation experiments into account, there can be no doubt that, in most cases, there would be a substantial profit from the use of the artificial mixtures if the effects on the subsequent crops could be shown.

5. So far as the swede crop of the present year is concerned, the nitrogenous dressing proved the most profitable of the Artificials used with Dung. Comparing Plots 3 and 9 it will be seen that 9s. worth of nitrogenous manure has increased the average crop by 2 tons per acre.

6. As in former years a "general" artificial mixture has paid better than a special mixture when used with Dung. (This is a subject on which further experimental evidence is required).

7. The most profitable artificial mixture for use without Dung consisted of:—

5 cwt.	Basic Slag		Costing 38s. per acre.
4 ,,	Kainit		
1 ,,	Nitrate of Soda		
¾ ,,	Sulphate of Ammonia		

A similar mixture containing 7 cwt. Superphosphate in place of 5 cwt. Slag, produced 12 cwt. more roots but at an extra cost of 10s. This mixture came second as regards profit.

8. The mixture containing Bone Meal did much better relatively when used with, than when used without, Dung.

9. In the case of the five farms of which the soil was found to be most deficient in available Phosphates, the soluble Phosphate in Superphosphate produced an average increase of 14⅘ tons per acre whilst the same quantity of insoluble Phosphate in Slag and in Bone Meal produced respectively 14⅘ tons and 13⅕ tons. In the case of the latter there is some evidence that the smaller average crop was due to the fact that half of the Nitrogen for the Bone Meal plot was supplied in an insoluble form. It would appear that as sources of Phosphate both Basic Slag and Bone Meal have been perfect, and in the first case at any rate, profitable substitutes for Superphosphate.

10. As in former years, heavy dressings of Dung have not proved profitable on the average, in certain cases they may prove economical, but present experience points to dressings of not more than 12 tons (18 to 20 loads) being the most suitable.

EXPERIMENT ON POTATOES.

An experiment on the Potato crop was carried out at six centres in the County of Durham. The names of the farms and other particulars will be found in the following Table:—

No.	Station.	Farmer.	Remarks.
1	East House Farm, Seaham Harbour	Mr. J. D. Dunn	Up-to-Date Potatoes on thin light soil, over stiff sub-soil, after oats on 2 years' lea.
2	Deafhill Colliery, Trimdon	„ Wood ...	Maincrop on light loam soil. after oats following potatoes. which were on 2 years' lea.
3	Stanley Hall Farm, Stanley	„ F. H. Burn ...	Up-to-Date Potatoes on light, rather gravelly soil, after oats on 3 years' lea.
4	Old Trimdon ...	„ W. T. Gregory	Up-to-Date Potatoes on light warm soil of good quality. after oats which followed turnips.
5	Edder Acres, Thornley	„ M. Swinburne	Up-to-Date Potatoes on strong soil, after 3 years' lea.
6	Hedley West House, Swalwell	„ J. Turnbull ...	Up-to-Date Potatoes on black loam, after 13 years' pasture.

Previous experiments in the manuring of the Potato crop are noticed at pp. 17 and 18 of the Report for 1898 and on pp. 42 to 50 of the Report for 1899. The experiment now to be described is to some extent a development of the experiment of 1899.

Last year's Report indicated that in season 1899, a heavy dressing of artificial manures costing 53s. 6d. per acre made a profitable addition to 12 tons of Dung and was in point of profit superior to either an 18-ton dressing of Fold manure or to 12 tons of the latter with light dressings of an artificial mixture. The Report further showed that Artificials without Dung had been very successful, and that Kainit was inferior to Muriate of Potash as a constituent of a potato manure. The experience of season 1899 may be representative of the conditions common throughout the county, but before coming to any definite conclusion respecting the best artificial mixtures for County Durham, it will be necessary to test a number of soils in different seasons. In 1900, therefore, a second group of farms was experimented upon, and in 1901, the work will be continued on others.

Objects and Plan of Experiment.—

The leading objects of the experiment of 1900 were:—

1. To ascertain how much artificial manure should usually be employed with 12 tons of Dung.
2. To compare certain common artificial manures as ingredients of a mixture for potatoes.
3. To test the effects of the manures used on the quality of the potato crop.

In 1899, the mixture which gave the best results consisted of:—

2½	cwt.	Sulphate of Ammonia	Per acre, costing 54s.
5½	,,	Superphosphate	
1	,,	Muriate of Potash	

In 1900, the standard mixture* consisted of:—

2¼	cwt.	Sulphate of Ammonia	Per acre, costing 46s.
3½	,,	Superphosphate	
1½	,,	Sulphate of Potash	

The experiment occupied ten plots; details of the treatment will be found in Table II., but it may be noted here that the general plan of manuring was as follows:—

Plot 1 received 12 tons (18 loads) of Fold manure per acre;

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* Supplying 52½ lbs. Nitrogen, 50 lbs. Phosphoric Acid, and 50 lbs. Potash, per acre.

Plot 2 received the Dung with *half* of, and Plot 3 the Dung with the *whole* of the above artificial mixture. No Dung was used except on the first three plots. Plot 4 received the standard artificial mixture; in Plots 5 and 6 Nitrate and Fish Meal respectively replaced half the Sulphate of Ammonia. Plot 7 got twice as much Sulphate of Potash as Plot 4 but in other respects the treatment was the same. In Plots 8 and 9 Muriate of Potash and Kainit were used instead of Sulphate of Potash. Plot 10 was unmanured.

The plots were 39 yards long and consisted of six 28 inch drills.* The four central drills, measuring $\frac{1}{40}$th acre, were weighed.

At one of the stations—Thornley—owing to the excessively wet weather it was only possible to weigh two drills from each plot.

The plots, except at Seaham Harbour where they were in two rows, were arranged thus:—

1, 2, 3,
6, 5, 4, 10,
7, 8, 9.

Notes on the Growing Crops.—

All the experimental plots were inspected in the middle of September, so as to ascertain the effects of the manures on the potato haulms; a search was also made for any inequalities that might be due to the soil, by examining both the plots themselves and the crop growing in the drills outside.

At Seaham Harbour the soil was uniform from end to end. The increase in haulm on Plot 2 as compared with Plot 1 was very marked. Between Plots 2 and 3 there was less difference. On Plot 4 where the potatoes were grown with the same Artificials as Plot 3, but without the Dung, there was a great falling off in haulm. There was again a recovery on Plot 5, which was the most vigorous looking of the plots getting Artificials only. Increasing the dressing of Potash made no difference to the appearance of the crop.

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* In some cases where the drills were 27 inches the plots were 40½ yards long.

At Old Trimdon the first six plots were very similar, Plots 5 and 6 being slightly the best. The leaving out of the Dung had very little effect on the haulm. Increasing the Potash made the tops distinctly lighter in colour and earlier, this was very marked in the case of Plot 9 (Kainit). It was distinctly inferior to the other manured plots.

At Trimdon, Plots 5 and 6 again promised best; there was no very apparent difference between Plots 3 and 4, and increasing the Potash did not affect the colour of the haulms.

At Stanley, Plot 4 was distinctly inferior to Plot 3, and also to Plots 5 and 6. Here too, the extra Potash had a marked effect in making the haulms lighter, and in the case of the Kainit, earlier. The contrast between Plots 9 and 4 which were next each other was very sharp, on the former the haulms were pale green, and the crop was ready to lift, on the latter the potato tops were dark coloured and showed no signs of ripening. The one crop was quite a month earlier than the other. It will be seen from Table II. that the crop of Plot 4 at Stanley was a very poor one, and that in this case the Kainit plot was not only the earlier but somewhat the better of the two. The soil at Stanley was not quite uniform, Plots 1, 6 and 7 had a slight advantage, but the difference was so slight as to cause no perceptible effect on the potatoes in the drills on either side of the experimental plots.

At Thornley after a three years' lea, artificial manures were found to do remarkably well without Dung, and to produce a very considerable improvement in the appearance of the crop when added to a dressing of Fold manure. Plots 4 and 5 looked very vigorous. Increasing the Potash produced a lighter coloured haulm and, as at other stations, this was most marked in the case of Kainit. The contrast between Plots 4 and 9 was again very striking.

At Hedley West House the soil was found to be variable and although the results have been given in Table II. they have been excluded from the average. The appearance of the crop here was very peculiar and it was impossible to explain all the peculiarities by variations in the soil, for some of the plots were sharply marked off from their neighbours, in a way that could only be accounted for by the difference in the manurial treatment. In the potato crop on either side although there were variations there was not the "chessboard" appearance of the experimental area. It was inferred from the appearance of the land and the effects produced by the Artificials that the soil needed lime, and it was therefore analysed. The surface soil was found to contain ·028 per cent. and the subsoil ·056 per cent. It is worth while recording that in this soil so abnormally deficient in lime the farmer had grown a fair crop of potatoes, with ½ cwt. of Nitrate and 3 cwt. of Superphosphate per acre for manure.

Average Results.—

For the purpose of contrasting the effects of the different manures on each farm it will be necessary to refer to Table II. where details are given, but for convenient reference the average crops and the profits for the various manures are given in the Table on next page.

Effect of Farmyard Manure.—

Comparing Plots 1 and 10 we see that a dressing of 12 tons of Fold manure valued at 60s. leaves a profit of 89s., and similarly comparing Plots 3 and 4 we find that the dressing of the former plot has been the more profitable by 11s. 3d. per acre. The return in the value of increased produce per ton of Dung is 12s. per ton in the former, and 6s. per ton in the latter case. If therefore, Dung is available, this experiment indicates that the potato crop will pay well for it.

It does not follow however that Dung is always either an essential or an economical potato manure. All will depend upon the position which the potato crop occupies in the rotation, and upon the supply of Dung that the farmer has at his command. There are numerous exceptions, but on most arable land the rule still holds good, that the best possible use for Dung is to apply it to clean fallow. If the potato takes its

Results of Experiment on Potatoes.

	Manuring per acre.	Per Acre.								
		Cost of Manures.		Average Yield of Large Potatoes on Five Farms.		Increase over Unmanured Crop.		Profit. (Potatoes valued at 60s. per ton).		
		s.	d.	T.	cwt.	T.	cwt.	£	s.	d.
1	12 tons. Farmyard Manure	60	0	6	17¼	2	8¼	4	4	9
2	Do., + half Artificials of Plot 4	83	0	8	2	3	13	6	16	0
3	Do., + Artificials of Plot 4	106	0	8	6¼	3	17¼	6	5	9
4	2¼ cwt. Sulphate of Ammonia. 3½ cwt. Superphosphate, and 1½ cwt. Sulphate of Potash	46	0	7	2½	2	13½	5	14	6
5	Same as 4, but 1½ cwt. **Nitrate** instead of 1⅛ cwt. Sulphate of Ammonia	46	0	7	8¾	2	19¾	6	13	3
6	Do., but 2⅞ cwt. **Fish Meal** instead of 1⅛ cwt. Sulphate of Ammonia, and 1 cwt. Superphosphate	48	0	7	12¾	3	3¾	7	3	3
7	Do., but **3 cwt.** Sulphate of Potash	54	6	7	19	3	10	7	15	6
8	Same as 7, but 1½ cwt. **Muriate** instead of 3 cwt. Sulphate of Potash	51	6	7	13¼	3	4¼	7	1	3
9	Do., but 7½ cwt. **Kainit** instead of 3 cwt. Sulphate of Potash	54	0	6	12½	2	3½	3	16	6
10	No Manure	—		4	9	—		—		

place in the regular fallow break then the crop should be grown with Dung, but if the potato is planted after two or more years lea it will usually do very well with artificial manures, and for the farm's sake the fallows should not be deprived of Dung in order to grow a potato crop. If it comes to a question of purchasing manure, Artificials will in general pay better than Dung, this at least is the teaching of the experiments of the past two seasons. If, for example, the Dung used last spring could have been purchased and applied for 5s. per ton and if we debit half of this sum to the potato crop, we find that the net profit from the manure comes to £5 14s. 9d., whereas the best of the artificial mixtures used on Plot 7 has left a profit of £7 15s. 6d. per acre, even if we assume that there has been no residue left in the soil for future crops.

Artificials used along with Dung.—

In last year's Report it was shown that heavy dressings of Artificials costing 53s. 6d. per acre had been profitably used along with 12 tons of Dung, and that from this heavy dressing larger profits were secured than from half the quantity. In season 1900, the smaller of the two artificial dressings used proved the more profitable. An application of about 3½ cwt. of mixed Artificials at a cost of 23s. has produced increase worth £3 14s. 3d. (compare Plots 1 and 2). On the other hand a further 23s. worth of purchased manure has produced but 12s. 9d. worth of potatoes. On three out of the five farms, however, the larger application was directly profitable, and when potatoes are worth 60s. per ton or more, a judicious expenditure of 40s. to 50s. on artificial manures to be used as an addition to 12 tons of Dung will seldom be unprofitable.

Artificial Manures without Dung.—

The dressing used on Plot 4 was similar to the mixture that gave such satisfactory results in 1899, and the mixtures for Plots 5 and 6 differed but little from it. The quantity of Sulphate of Ammonia used on Plot 4 was very large and the object of adding Plots 5 and 6 in 1900 was to ascertain whether it would not be better to use a mixture of two nitrogenous manures instead of so much of the one kind. At most of the centres there was a very distinct benefit from the mixture, and on the average, Plot 5 was 18s. 9d., and Plot 6, 27s. 3d. per acre better than Plot 4. The latter plot was at a slight disadvantage at Stanley, but at Thornley it had a corresponding advantage, and the comparison on the five stations is a fair one.

Effects of increasing the Potash.—

The general effects on the haulm have already been referred to. In September there was no indication that the additional application of Potash was doing good, but on two out of three plots it has been productive of a substantial increase. Between two of the potash manures there is little to choose, the Sulphate was slightly the better last season. On the other hand Kainit, the commonest of the three, has proved inferior to the others. There was not much difference in the yield of Plots 4 and 9, and the chief objection to the use of heavy dressings of Kainit is that this manure may injure the quality of the crop.

Samples of the potatoes grown on certain plots were analysed and Table III. gives the percentage of dry matter. It will be remarked that in one or two cases, the reduction in the dry matter, consequent upon the use of Kainit, has been considerable, and at one centre the tubers lost over 20 per cent. of their food value when Kainit was substituted for Sulphate. The decrease in the dry matter is doubtless caused by the early ripening of the crop. At both Stanley and Thornley Plot 9 was characterized by a pale yellow-green haulm, and a strong tendency to ripen prematurely. It is not likely that moderate applications, say 3-4 cwt. of Kainit will be found injurious, but if a farmer decides upon using a heavy dressing of a potash manure it will be safer to employ either the Sulphate or the Muriate than Kainit. A reference to the table given above will show that, though Muriate and Sulphate are much more expensive "per ton" than Kainit, the cost per 100 lbs.* of Potash is very nearly the same in each case.

Summary.—

An experiment on the manuring of potatoes was conducted at six farms in Co. Durham in 1900. In one case the soil proved unsuitable for experiment, of the results on the five remaining farms the following summary may be made:—

---

* Plots 7, 8 and 9 each received 100 lbs. Potash per acre,

(1) A dressing of 1⅛ cwt. Sulphate of Ammonia, 1¾ cwt. Superphosphate and ¾ cwt. Sulphate of Potash costing 23s. per acre, proved to be a very profitable addition to 12 tons of Farmyard manure, and slightly more profitable than double the quantity of Artificials.

(2) The most profitable mixture of Artificials for use without Dung consisted of 2¼ cwt. Sulphate of Ammonia, 3½ cwt. of Superphosphate and 3 cwt. of Sulphate of Potash. This mixture cost 54s. 6d. per acre.

(3) From the results obtained on Plots 5 and 6, it seems probable that the above mixture would have been more profitable than it was, if ½ cwt. Nitrate of Soda and 1 cwt. Fish Meal had been substituted for 1 cwt. Sulphate of Ammonia.

(4) The profits were greater with the dressing given in No. 2 above, than with Dung and Artificials. When the potato occupies a portion of the fallow break, Dung should be used; when it does not, these experiments, and those made in 1899, indicate that Fold manure may sometimes, with advantage, be omitted, and artificial manures only used.

(5) In the absence of Dung, heavy dressings of Sulphate and Muriate of Potash have proved advantageous; heavy dressings of Kainit have, on the other hand, somewhat decreased the yield. In two instances it was noticeable that Kainit hastened ripening. In both these cases the percentage of dry matter in the potato crop was much reduced. On every one of the five farms, and also at Cockle Park, the use of Kainit lowered the percentage of dry matter. The average reduction amounted to 2·88 per cent. of dry matter, which means that the food value of 8 tons of potatoes grown with Kainit, was, on the average, no greater than that of 7 tons grown with Sulphate of Potash.

EXPERIMENT ON SEEDS HAY.

An experiment on Clover and Rye-grass hay was made on the following farms:—

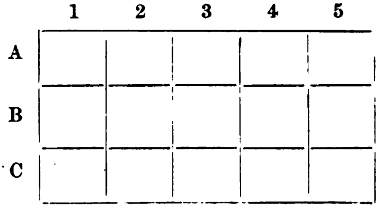
No.	Farm.	Occupier.	Remarks.
1	Thorpe Thewles, Ferryhill.	Mr. W. T. Parkin.	Good take of seeds; after wheat.
2	Sth. Causey Farm, Shield Row.	Mr. J. Watson.	Fair take of seeds, but injured by late frost.
3	Stanley Hall Farm, Stanley.	Mr. F. H. Burn.	Poor soil and poor take of seeds.
4	Offerton Hall, Sunderland.	Mr. J. Maclaren.	Very good take of seeds.
5	Witton Hall, Witton Gilbert.	Mr. T. R. Holmes.	Good take of seeds after oats.
6	White House, Lanchester.	Mr. U. A. Ritson.	Seeds injured by frost.
7	Old Durham Farm, Durham.	Mr. R. H. Hopps.	Very fine take of seeds.
8	Low Raisby, Kelloe.	Mr. R. N. Lee.	Take of clover good, but soil rather variable.
9	Deafhill Colliery, Trimdon.	Mr. W. Wood.	Seeds good.
10	Whitehurworth, Trimdon.	Mrs. Potts.	Seeds good, but land not quite even.
11	Binchester Crag, Byers Green.	Mr. J. Hutchinson.	Fair take of seeds.

Object and Plan of Experiment.—

A heavy crop of hay is an especially important consideration in the county of Durham on account of the demand created by the Collieries, and the sale of hay being very common the crop will pay for a more liberal use of manure than if it were grown for home consumption.

The object of this experiment was to obtain information respecting Nitrate of Soda, Sulphate of Ammonia, Superphosphate, and Kainit when employed either alone, or as ingredients of a mixed manure for top-dressing first year seeds.

An acre of land was divided into fifteen parts as shown below:—



The five plots on Section A were treated thus:—

Plot 1. No Manure.
„ 2. 1½ cwt. Sulphate of Ammonia, per acre.
„ 3. 2 „ Nitrate of Soda „
„ 4. ¾ „ Sulphate and 1 cwt. Nitrate per acre.
„ 5. Half the dressing of Plot 4.

Each plot in Section B was treated in the same way as the corresponding plot on Section A and in addition received 4 cwt. of Kainit per acre. On Section C there was an addition of 4 cwt. of Superphosphate per acre to the manures used on Section B, thus Plots 2 to 5 C were getting a complete manure.

The manures were applied early in April with the exception of the Nitrate, which was put on in the beginning of May when the grass began to grow. The high winds that prevailed in the end of March and first part of April delayed the application of the Superphosphate and Kainit to a later date than was desirable.

At ten of the eleven centres the crops were weighed. The weights will be found in Table IV. The grass was weighed green and 30 per cent. of the weight was taken as representing the crop of hay. At four of the stations irregularities in the soil or in the "take" of seeds have affected the results, and the crops have not been included in making up the averages, nor do the remarks which follow apply to them.

Average Results.—

A reference to the diagram which gives the position of the plots will show that they were arranged in groups. Each of the nitrogenous manures was applied to three separate ⅕-acre plots (2A, 2B, 2C, etc.); five plots (Nos. 1-5B) received a potash manure, and five plots (Nos. 1-5C) were dressed with Superphosphate. These groups of plots form series, which though not exactly duplicates, may be treated as duplicates and "averaged." This has been done in the following Table. To ascertain the effect produced by Sulphate of Ammonia, for example, we compare the averages of Plots 2A, B and C, and 1A, B and C; to ascertain the effect of Superphosphate, Plots 1-5C have been compared with 1-5B.* The averages given have been taken from Table IV.

Plots.	Manuring per acre.	Cost of Manures.	Average of Six Farms.			Offerton Hall.	Thorpe Thewles.	Binchester Crag.	Old Durham.	Witton Hall.	Shield Row.
			Yield.	Increase.	Profit or Loss (-).						
		s.	cwt	cwt	s.	cwt	cwt	cwt	cwt	cwt	cwt
1 A, B, and C	No Nitrogenous Manure.	—	30½	—	—	36	33¼	27¼	41	30	15
2 " " " "	1½ cwt. SULPHATE OF AMMONIA.	18/	40	9½	10/6	52	38¾	36¾	45¼	35½	31¾
3 " " " "	2 " NITRATE OF SODA.	18/	42½	12	18/	53¼	43	38	45	43¾	32
4 " " " "	¾ " SUL. AM., 1 cwt. NIT. SODA.	18/	43	12½	19/6	54¼	42¼	38¾	46	47¼	29
5 " " " "	Half the Dressing of Plot 4.	9/	37	6½	10/6	46¾	34	32¾	43¾	41½	23¼
1—5 A	Average of Section A, without Kainit.	12/7	37½	—	—	46¼	36	33¼	44¼	39	27
1—5 B	" " B, with KAINIT, but without Super.	21/7	38	½	- 7/6	46¾	38¼	33¼	44¼	39	26¾
1—5 C	" " C, with Kainit and SUPERPHOSPHATE.	33/7	40	2½	-13/6	52½	40½	37¾	44¼	40½	24¾

Sulphate of Ammonia and Nitrate of Soda.—

Both manures have produced a profitable increase, but on the average Nitrate has been much more profitable than Sulphate. At two out of six farms the manures were practically equal, at two the Nitrate had a slight advantage and at the remaining two a very decided advantage over the

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* To this method of averaging it may be objected that manures produce different effects in different combinations. This is true, but if the details in Table IV. are studied, it will be seen that in this particular case any disadvantages due to averaging the results produced by manures in different combinations, are more than compensated for by the advantages of treating the plots as duplicates.

Sulphate. When the crops were inspected the Nitrate plots looked much the more vigorous, and as 13 out of 18 plots actually grew more hay it is clear that last season the quicker acting of the two manures was the better.

Plot 4 got half of the combined dressings of Plots 2 and 3, and the mixture of Nitrate and Sulphate was better than either of the two used alone. The superiority over Nitrate was very slight, and, so far as the results of season 1900 are concerned, the effects of 2 cwt. of Nitrate and of 1 cwt. along with ¾ cwt. of Sulphate may be looked upon as equal. To some extent the choice between these manures is a question that depends on the soil, but it more often depends upon the season and their market values. When the two cost about the same per unit of Nitrogen, the best plan is to employ both. For the hay crop a suitable proportion would be ⅔ Nitrate and ⅓ Sulphate.

Of the dressings used on Plots 4 and 5 the larger was much more profitable than the smaller, and when the object is a heavy hay crop and the seeds are not to lie for a second year, 1½-2 cwt. of the mixed manure may often be profitably employed by a prudent farmer.

But for general use on rye-grass and clover hay not more than 1 to 1¼ cwt. can be recommended, and where the clovers are of more consequence than the grasses, less should be employed.

Effect of Kainit.—

On one farm in six (Thorpe Thewles) the potash manure produced an average increase of 2½ cwt. per acre, but the increase was not of a very satisfactory character as it was considerable on some plots and non-existent on others; further, this increase was not due to the effect of Potash on the clover, for the clover was distinctly weaker on the "B" than on the "A" plots. On the average Kainit has not in any way improved the hay crop when used along with nitrogenous but without phosphatic manures.

Potash manures very frequently exercise a beneficial effect on the clover crop but, except at Cockle Park where the soil is very deficient in "available" Potash, we have not yet obtained distinct evidence of their value as top-dressings for seeds.

In the first rotations at Peepy and Whitefield it was proved that the omission of Kainit from a general mixture, applied for roots grown without Dung, reduced the value of the four crops by £3 7s. 0d. per acre. On the same soils top-dressing with 4 cwt. of Kainit failed, last season, to benefit the seeds, the third crop of the second rotation. The land got 12 tons of Dung for the first crop of the second rotation but no artificial potash manure until the spring of 1900 (see Table VII.). At Rose Bank, see p. 196, and at Kimblesworth, a top-dressing of Kainit has also failed to affect the weight of the hay crop. Cockle Park, on the other hand, has afforded evidence of the beneficial influence of the potash manure both on the quantity and quality of clover hay.

The remarks made apply to Kainit when used as part of a special dressing, but an examination of the yields on Plots 1-5c (Table IV.), where it was employed as part of a general manure, will indicate that it cannot have been of much service.

At one farm, White House, Lanchester, where the experimental plots were high-lying and exposed, there was a severe frost a few days after the manures had been applied. The clovers all over the field were injured, but those on the plots that had received Kainit were practically destroyed. At two other stations in the same vicinity it was remarked that the clovers had suffered in the same way. Apparently the crude potash salt, which contained about 60 per cent. of common salt, had reduced the freezing point below 32° F., and had produced an intensity of cold that was fatal to the young clover plants.*

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* This explanation was suggested by Mr. Collins.

On account of the large quantity of common salt which Kainit contains, farmers are frequently advised to apply the manure very early "so that the impurities may be washed out." If the advice is acted upon, care should be taken that the weather is moist and open. If the soil is dry and the nights are frosty there is apparently some risk of doing harm.

In connection with possible injury by the salts contained in Kainit, the results obtained from the second cutting of hay at Offerton Hall and Thorpe Thewles may be mentioned. The "B" plots at both stations were inferior to the "A" plots, at the former the difference was very marked. Where Superphosphate had been used (on Section C) the aftermath was better, but the crops were no heavier where a general manure was employed than where the seeds received nitrogenous manures alone. The best second crop on both farms was cut on Plot 1c.

Effect of Superphosphate.—

On three farms out of the six, and on sixteen plots out of thirty, a dressing of 4 cwt. of Superphosphate has increased the crop. On two of the farms the increase has been directly profitable. At Offerton Hall where the improvement was most marked, the additional manure, costing 12s., produced an increase of 6 cwt. of hay. The field on which the trial was made at Offerton Hall was close to Flinton Hill, where the "Swede Experiment" showed the soil to be very deficient in "available" Phosphates, and it is likely that on all the East Durham farms named on p. 18 a dressing of Superphosphate would profitably increase the hay crop. As in the case of Potash more evidence is wanted regarding the practice of top-dressing seeds with Superphosphate. From the trials made in this district in the past, it would seem that in many instances it will not pay, but that on land naturally deficient in Phosphoric Acid, as at Cockle Park, or the district in East Durham just mentioned, money is often lost by withholding a dressing of soluble Phosphates in the spring.

Summary.—

An experiment on the manuring of seeds hay was carried out at eleven centres in Co. Durham. From six of the centres consistent results were obtained. The effects of the manures on the *weight* of the hay crop were as follows:—

(1) Nitrate of Soda proved more generally useful than Sulphate of Ammonia.

(2) Kainit was unprofitable. It increased the yield on one farm only and then it did not pay.

(3) Superphosphate caused a profitable increase on two farms only.

(4) The most profitable manure consisted of 1 cwt. of Nitrate and ¾ cwt. Sulphate; but 2 cwt. of Nitrate did almost as well.

(5) These heavy dressings of nitrogenous manure must be used with caution. They may appear to be profitable without actually being beneficial, for they may injure the clover crop. See remarks on p. 152 and also composition of clover hay differently manured, Table XXIII. The injury may at times be prevented by the use of phosphatic and potash manures.

ROTATION EXPERIMENT AT KIMBLESWORTH, CHESTER-LE-STREET.

The first rotation of the experiment on this farm, occupied by Mr. George Liddell, concluded with the oat crop of 1900.

Details of the manuring together with the results for five years are presented in Table V.

The crops grown were potatoes in 1896, barley in 1897, hay in 1898 and 1899, and oats in 1900. With the exception of Plots 6, 15, 16, 17, 18 and 20 the manures were all applied to the first crop.

The chief objects of the experiment were:—

1. To show the effects of Farmyard manure when used in quantities varying from 12 to 24 tons per acre (Plots 10, 19, 21, and 22).
2. To indicate the effects of using Artificials without Dung (Plots 10 and 20).
3. To discover which ingredient of the artificial manure was the most useful (Plots 5-10).
4. To ascertain what quantity of each ingredient should be used with 12 tons of Dung (Plots 1-5).
5. To compare the common phosphatic manures Superphosphate, Slag, Dissolved Bones, and Bone Meal (Plots 5, 6, 11, 12, 13).
6. To test the advisability of blending the foregoing, instead of using them separately (Plot 14).
7. To find out whether it is best to give all the Artificials to the first crop or to spread them over the Rotation (Plots 14-18).

On all these points, with one exception (No. 4), the figures in Table V. give reliable, and in most cases, definite information.

The twenty-two $\frac{1}{5}$th acre plots contained in the experiment lay side by side from 1—22. Each plot was 297 feet by 29 feet 4 inches, the first four were on a slight side slope, the remainder were on a slight and uniform slope along their length, the slope was the same for all, and the ground was of very even quality. The soil was a medium loam, naturally "hungry," but clean and in first-rate condition for experimental purposes. The depth (6 to 7 inches) was uniform, with the exception of a patch of about 50 square yards in Plot 14, which was an inch shallower than the rest.

The cultural details were carefully carried out by Mr. Liddell; the crops, with the exception of the barley crop of 1897, were good, and the figures may be accepted with confidence as containing the "exact" experience gained on a well managed farm lying on the Boulder Clay and representative of the Team Valley District of County Durham.

With the object of enabling the reader to follow the detailed results more readily two diagrams have been prepared. The first of these will be found on the opposite page, and before dealing with its lessons, its uses may be briefly indicated. Each crop is represented by a vertical line (the two hay crops by one line), the length of which shows the value of the crop as measured by the scale at the side of the diagram. In referring to the diagram the value of the five crops should first be noted and then the upright lines should be compared. It will often help the comparison if a ruler or a sheet of paper is laid across the diagram at certain heights. If for example a ruler is set at the level of the unmanured barley crop, the effects of each manure on this crop will be readily followed.

Effect of Artificials used alone.—

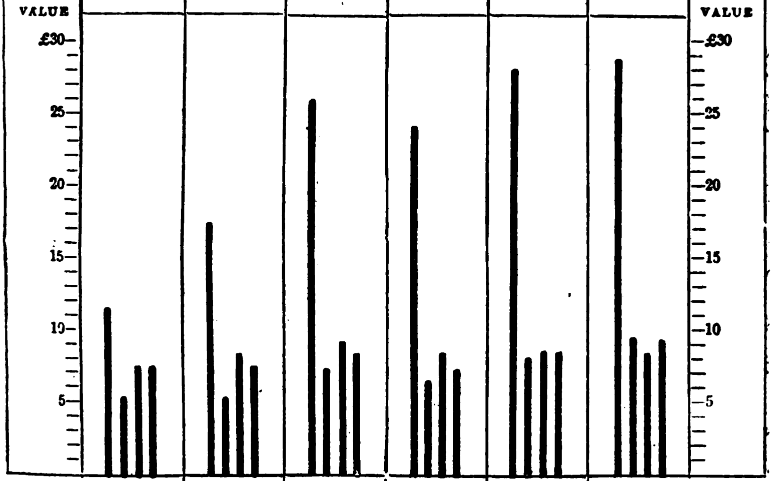
The first comparison on the diagram opposite is made between the unmanured plot and Plot 20, which had a very liberal dressing of Artificials, partly applied to the potato and partly to the subsequent crops. The effects have been dis-

DIAGRAM I.—KIMBLESWORTH ROTATION.

Diagram illustrating the effects of—

(1) using dung alone and artificials alone, compare Plots, 10, 19, and 20.
(2) using dung with artificials, compare Plots, 19, 20, and 17.
(3) increasing the dressings of dung, compare Plots 10, 19, 21, and 22.

FIGURES PER ACRE.



	Plot 10	Plot 20	Plot 17	Plot 19	Plot 21	Plot 22	
	No Manure.	22 Cwt. Artificials.	12 Tons Dung and 22 Cwt. Artificials.	12 Tons Dung.	18 Tons Dung.	24 Tons Dung.	
Value of 5 Crops	£31 16 0	£38 16 0	£51 1 0	£46 9 0	£53 0 0	£56 0 0	Value of 5 Crops
Cost of Manure	———	£3 14 0	£6 14 0	£3 0 0	£4 10 0	£6 0 0	Cost of Manure

The first (long) line shows the value of the Potato Crop on each plot.
The second line shows the value of the Barley Crop.
The third line shows the value of the two Hay Crops.
The fourth line shows the value of the Oat Crop.

All manures to Potatoes, except on Plots 17 and 20, where half of the Artificials were spread over the subsequent crops. The Artificials for these plots consisted of 10 cwt. Kainit, 4 cwt. Super, 2½ cwt. Slag, 1⅝ cwt. Dis. Bones, 1¾ cwt. Bone Meal, 1⅝ cwt Sul. Am., and ⅝ cwt. Nit. Soda.

appointing, the total increase obtained amounts to not more than £7 worth of produce per acre, whereas when a dressing of Farmyard manure has been employed, the increase has been worth more than double this sum. The potatoes, although a poor crop on Plot 20, have been responsible for nearly all the increase, and the poverty of the corn and hay crops, though liberally top-dressed shows how necessary the application of Dung is on the Kimblesworth soil. Apart from the inferior tilth due to the absence of a bulky organic manure, the chief reason for the poor effects produced by Artificials at Kimblesworth is the fact that the mixture was deficient in soluble nitrogenous manures, which the experiment indicates were most necessary.

Effect of Farmyard Manure.—

A comparison of Plots 19 with 10, and 17 with 20 brings out clearly the importance of Fold manure on the Kimblesworth soil. A dressing of 12 tons, which may be assumed to be worth £3, has increased the value of the crops by £14 13s. in the first instance and by £12 5s. in the second. Further, a comparison of Plots 19, 21 and 22 shows that an application of 18 tons of Dung has been very profitable, and that, even when the dressing has been increased from 18 to 24 tons, there is still a direct profit. In few, if any, of our experiments has a heavy dressing of Dung proved as effectual as at Kimblesworth, and it is especially interesting to notice that in this final application the profit has not been due to the potato crop, but to the improved condition of the soil for corn growing. Both barley and oats have done remarkably well on Plot 22. It must be remembered, however, that the seasons were favourable. If the barley crop of 1897 had been a heavy one, the crop on Plot 22 would in all probability have lodged and been spoiled. It is curious to notice how slightly the hay crops have been affected by increasing the dressings of Dung. The heavy crop of barley straw on Plot 22 would tell against the first year's seeds, and it was probably this that made the first hay crop a very moderate one, no better than that produced on the land getting only half as much Dung, and fifteenth in order of merit; but the second year's hay, though a light crop, was the fourth best cut from the twenty-two plots.

In spite of the unmistakable proofs that heavy manuring suits Kimblesworth soil, it will be seen that, apart altogether from the danger of "lodging" the barley crop and ruining the seeds, it is only when Dung is very abundant, or easily purchased, that it would pay to use as much as 24 tons per acre. If we refer to Plots 19, 21 and 22 we find that, the first application of 12 tons per acre gave a return of 24s. 6d. per ton of Dung (compare Plots 19 and 10) the second application of 6 tons per acre gave a return of 22s. per ton (Plots 21 and 19) and the third application of 6 tons per acre gave a return of 11s. 8d. per ton of Dung (compare Plots 22 and 21). There is a rapid falling off therefore when we pass 18 tons per acre, and, though any farmer might be well satisfied with the lowest return for a ton of Dung above shown, there is no reason why he should remain satisfied with it, if by distributing the manure at a less rate over a larger area he can get still greater returns. It will, of course, already have been noticed that the very high returns per ton of Dung, and the high returns generally, are due to the fact that Mr. Liddell grew an excellent crop of potatoes in 1896. The line that stands for the potato crop in the diagrams, plainly shows how much the profits made by the different manures throughout the whole rotation, depend on the way in which the first crop has been suited by the dressings used.

Effect of Artificials when used to supplement Dung.—

The joint effects of Dung and Artificials have already been alluded to in connection with Plot 17, but the particular application of Artificials here used was not very well calculated to bring out the value of artificial manures, and the plot was selected because of its close relation to Plots 19 and 20.

Judging from the general results obtained on other plots one would infer that Plot 20 got too much Kainit, too much phosphatic manure, and too little plant food in the form of soluble nitrogenous dressings. The artificial mixtures which have done best in this experiment were those containing Superphosphate, Kainit, and either Nitrate of Soda or Sulphate of Ammonia. In the diagram on page 45 the results on a plot called 6A have been given, and as this plot has received one of the best mixtures, we may use it to show the effects of adding Artificials to Dung at Kimblesworth.

"Plot" 6A is a composite one made up of the first two crops of Plot 6 and the remaining three of Plot 5. Plot 6 got supplementary dressings of Sulphate of Ammonia for the hay and oat crops, and as it was the only one which received Sulphate in addition to Superphosphate and Kainit for the potato crop, it is necessary to take it for comparison with Plots 11-14, and to assume (as has been done in 6A) that the last three crops on Plot 6, if they had got no further manure, would have equalled the last three on Plot 5; so far as the manuring of the two plots went there is no reason to suppose that there would have been any difference.

On the majority of tillage farms the legitimate use of artificial manure is as a supplement to a moderate dressing of Dung. We have already seen that 6 tons of Dung used as a supplement to 12 tons on Plot 21 has been very profitable and we may compare the effects of the artificial dressing of Plot 6A with the effects of 6 tons of Dung on 21. The Artificials have cost 35s. 2d. and have grown produce worth £6 13s.; the Dung, worth say 30s. has increased the yield by £6 11s., practically therefore the Dung and Artificials have been equally useful. The former produced the better potato and the latter the better oat crop. There is no evidence to show that at the end of the five years rotation the plot that received 18 tons of Dung was in any better condition than the plot that got 12 tons with an artificial mixture. We find then that *Artificials have proved a* *perfect substitute for a part of a dressing of Dung,* and if they have been satisfactory at Kimblesworth, on a soil markedly benefited by Fold manure they are not likely to fail when similarly used elsewhere.

The most important constituent of the Artifcial Mixture.—

The conclusion just come to, depends, of course, on the proper artificial mixtures being used, used in proper quantity, and used in the best way; and we may next examine the evidence of the Kimblesworth experiment on these subjects.

As regards the most important constituent of the mixture the evidence of Plots 6A, 7, 8, 9, and 19 is clear; this may be seen from the following figures.

Plot.	Manuring per Acre.	Gross Value of five Crops.			Decrease in Value.*		
	12 Tons Farmyard Manure with:—	£	s.	d.	£	s.	d.
6A	1½ cwt. Sulphate of Ammonia, 5 cwt. Superphosphate, 5 cwt. Kainit. **(Complete Artificial Manure.)**	3	2	0		...	
7	1½ cwt. Sulphate of Ammonia, 5 cwt. Super., **no Kainit.**	52	7	0	0	15	0
8	1½ cwt. Sulphate of Ammonia, 5 cwt. Kainit, **no Superphosphate.**	49	15	0	3	7	0
9	5 cwt. Superphosphate, 5 cwt. Kainit, **no Sulphate of Ammonia.**	45	16	0	7	6	0
19	**No Artificials.**	46	9	0	6	13	0

* As compared with Plot 6A.

Thus a saving of 12s. in the purchase of Kainit in 1896 has resulted in a loss of 15s. worth of crop over the next five years; 13s. saved in the outlay for Superphosphate, has resulted in a loss of 67s.; and 10s. saved on Sulphate has decreased the returns of the five years by 133s. Nitrogen is obviously the most important constituent of an artificial mixture for Kimblesworth; Superphosphate and Kainit without Sulphate, have produced no effect at all on the gross returns, though they have apparently been of some service to the corn crops.

Which is the most useful of the Common Phosphatic Manures?—

This question was dealt with on Plots 6, 11, 12 and 13. Plots 6 and 12 were supplied with soluble Phosphates in the form of Superphosphate and Dissolved Bones respectively, and Plots 11 and 13 received insoluble Phosphate of Lime in Basic Slag and Bone Meal. The applications of insoluble Phosphate were 50 per cent. greater than of the soluble Phosphates. Apart from the phosphatic dressings the manuring of each plot was the same except that on 12 about one half, and on 13, about two-thirds of the Nitrogen was supplied in Bone manures instead of by Sulphate of Ammonia.

The results obtained on each of these four plots are shown in the diagram on page 45. For reasons already stated a plot named 6A has been substituted for 6 in this diagram.

As in a similar experiment made at Peepy and Whitefield, the Superphosphate plot proved best of the four, and the total value of the crops is nearly £4 more than on any of of the others. Slag occupies the second place and the Bone manures have both been disappointing. The chief difference—and it was very marked—was in the potato crop, and here the fact that an organic manure partially replaced the Sulphate of Ammonia doubtless accounts for the result more than the change of Phosphate. The barley was best on the Slag plot and the oats on the Superphosphate plot. Bone Meal gave no proof of its reputed lasting effects.

Complex Manures.*—

A mixture consisting of one fourth of the collective dressings of the four plots which have just been mentioned was applied to Plot 14, the result was a yield worth £46 18s. 0d., or

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* A complex manure may be described as one in which the Nitrogen, Phosphates, or Potash are one or all supplied from two or more distinct sources, for example, the dressings used on Plots 12-18 at Kimblesworth, and the Artificials used at Rose Bank. A simple mixture is one in which the Nitrogen, etc., come from a single source, as on Plots 1-6 at Kimblesworth.

DIAGRAM II.—KIMBLESWORTH ROTATION.

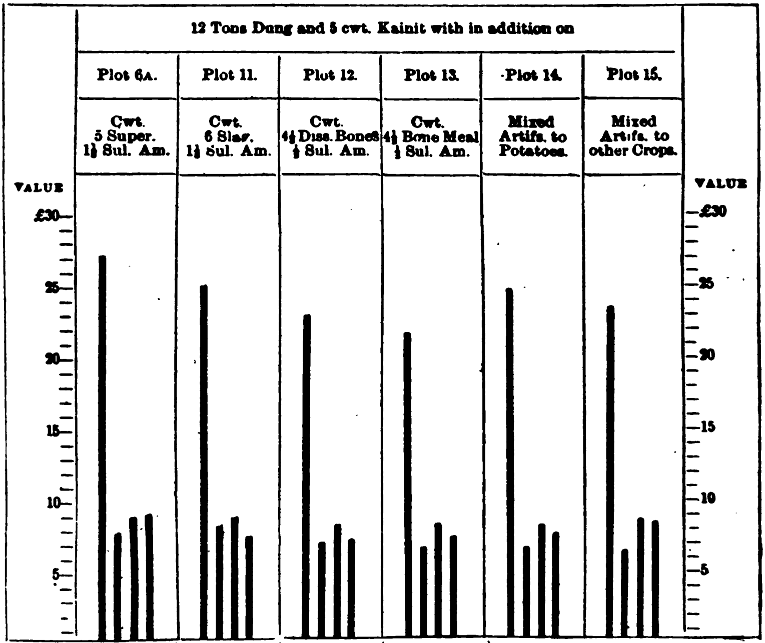
Diagram illustrating the effects of :—

(1) using various phosphatic manures, compare Plots 6A, 11, 12, and 13.

(2) using a complex artificial dressing, see Plot 14.

(3) using all artificials for Potatoes (Plot 14), and spreading the artificials over subsequent crops (Plot 15).

FIGURES PER ACRE.



Value of 5 Crops.	£53 2 0	£49 16 0	£45 15 0	£44 3 0	£46 18 0	£47 5 0	Value of 5 Crops
Cost of Manure	£4 15 2	£4 16 3	£4 18 2	£4 18 8	£4 17 1	£4 17 1	Cost of Manure

The four lines in each plot represent the values of the Potato, Barley, two Hay, and Oat Crops respectively.

Plot 6A.—In this case the Potatoes and Barley were grown on Plot 6, the Hay and Oats on Plot 5, which was manured as Plot 6, but received 1½ cwt. Nitrate instead of Sulphate.

The mixed artificials for Plots 14 and 15 are made up of ⅕ of the collective dressings of Plots 5, 6, 11, 12, and 13, and amount to half the artificials given to Plot 20. All manures applied to the Potato Crop except on Plot 15.

23s. less than the average value of the crops grown on the four plots. This result confirms the findings of the Northumberland experiments* and indicates that the arable farmer who has ascertained what Phosphate or other Artificial gives best results on his soil, need not trouble himself with complex manures.

Our experience in the treatment of old grass land has been quite different; however well any one manure may do, we generally find that mixtures, supplying Nitrogen and Phosphates in several different forms, are the most profitable.

It is easy to explain in a general way why this should be so. On arable land all the plants composing a crop make their growth at the same time, their wants are similar and what suits one plant suits the other (the hay crop forms an exception). On the meadow there are numbers of different plants, having a somewhat different season of growth and different root range; they want food, not only at different times, but at different depths in the soil, and these requirements are more likely to be met by a complex manure than by a simple one.

There are two common exceptions which may be made to the statement that simple manures should be used on tillage land. In this district Superphosphate and Slag are often found to be equally profitable when the same money values of each are used, in this case it will be best to employ both. The same may be said of Nitrate of Soda and Sulphate of Ammonia; so far as soil and crop are concerned it is often a matter of indifference which is used; in one season the former, and in another the latter will give the better results. Since the action of these two manures depends so much upon season, the use of both may be recommended to any farmer who has not definitely proved that one is better than the other for his land.

Should Artificials be distributed throughout a Rotation?—The important question as to whether it is better to apply (as is usual) the greater part of the artificial manure to the roots, or to spread it over the rotation, will be discussed in connection with the results of the Rose Bank experiment, and meantime we may note that at Kimblesworth, where this question was tested on five plots, there was no decisive answer; on the whole one system paid as well as the other. It is interesting, however, to note the effects of the different systems on the individual crops as shown in the following summary taken from Table V.

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* At Peepy and Whitefield.

Plot.	Manuring per Acre.	Value of Crops per Acre.									
		Potatoes.		Barley.		Hay (2 crops).		Oats.		Total.	
		£	s.	£	s.	£	s.	£	s.	£	s.
14	12 tons Dung, with, in addition, 11 cwt. Artificials to Potatoes	24	19	6	7	8	1	7	11	46	18
15	No Artificials to Potatoes, but 11 cwt. to subsequent crops	23	6	6	11	8	18	8	10	45	5
18	5½ cwt. Artificials to Potatoes, and 5½ cwt to subsequent crops	23	15	5	19	8	12	7	12	45	18
16	Double Artificials of 14 to Potatoes (less 5 cwt. Kainit which was distributed over the four last crops)	25	14	8	5	8	17	8	13	51	9
17	11 cwt. Artificials to Potatoes, and 11 to subsequent crops	25	18	7	5	9	6	8	12	51	1

It is remarkable that the barley crops on Plots 14 and 16 should have been considerably better than they were on Plots 18 and 17, and we have here an indication that the best way of supplying Phosphates to barley is to employ a phosphatic manure for the previous root-crop. Top-dressing has improved the oat crop on Plot 15, but it has failed to do so on Plots 18 and 17. The hay crops have been slightly improved but the improvement is no more than is to be expected from the soluble nitrogenous manures used. Neither from the hay nor oats have we any distinct indications that the top-dressings of Phosphates and Potash have been beneficial.

Effect of Top-dressing with Sulphate of Ammonia.—

Plot 6 received somewhat heavy dressings of Sulphate of

Ammonia for both hay crops, and for the oat crop. The manure cost 40s. 6d. and the increased crops were worth only 38s. so that this top-dressing did not pay, although it produced more marked effects than any of the other top-dressings employed. Its chief value was for the oat crop; it increased the yield of grain by 7 bushels per acre, although curiously, there was less straw than on several of the plots that got no manure in spring.

Summary.—

(1) The Kimblesworth experiment was carried out on a five-year rotation of crops,—potatoes, barley, hay, hay, and oats. There were twenty-two $\frac{1}{5}$th acre plots. The soil was suitable and the details were carefully carried out. The results were in most cases consistent.

(2) Farmyard manure in heavy dressings proved unusually profitable. If 18 tons per acre had been available for the whole of the root crop Artificials could not have been used with profit.

(3) As a supplement to 12 tons of Dung certain artificial mixtures proved very profitable, but when used alone, artificial manures gave poor results. The best mixture for use with 12 tons of Dung consisted of 1⅛ cwt. Sulphate of Ammonia, 5 cwt. of Superphosphate, and 5 cwt. of Kainit. This mixture costing 35s. increased the gross value of the crops by £6 13s. per acre.

(4) When used as a supplement to Dung the most important ingredients of the artificial mixture were Nitrate and Sulphate.

(5) Superphosphate proved to be the best of the phosphatic manures.

(6) A complex manure was not the most profitable.

(7) Spreading the Artificials over the rotation did not increase the gross returns.

(8) Supplementary dressings of Sulphate of Ammonia to the hay and oat crops cost 40s. 6d. and increased the value of the crops by 38s.

ROTATION EXPERIMENT AT ROSE BANK, DALSTON.

This experiment is one of two that were laid out in Cumberland in 1896; as the other, at Whitehall, has not been completed, it will be dealt with in a subsequent report. The land for the Rose Bank experiment was placed at the disposal of the County Council and the College, by Mr. R. Tinniswood, and the details were carried out by him, with the assistance of Mr. Lawrence. The crops were swedes in 1896, followed by oats, hay, hay, and oats in the four subsequent years. The area of the station was 6 acres, divided into twenty-four ¼-acre plots.

The objects of the experiment were:—

1. To ascertain what quantity of Farmyard manure may be most profitably employed in cases where artificials are not used. Quantities of 6, 9, 12 and 15 tons per acre were applied for the swedes on Plots 4, 8, 12 and 15 respectively. (See Table VI.).
2. To compare the effects of a mixed artificial manure when used alone, and as a supplement to Dung (Plots 1, 5, 9, 13 and 16).
3. To ascertain whether artificials should be applied to the root crop only, or spread over the rotation (Plots 2, 3; 5, 6; 9, 10; 13, 14, 22; 23, 24; 16, 17; 19, 20, 21).

Mr. Tinniswood describes the soil as a poor loam of medium texture, containing fragments of freestone. It is neither heavy nor light. It represents the ordinary moorland of the district, and beneath a surface covering of 8 or 9 inches of soil, there is the stiff impervious clay "pan" characteristic of moorland. The land on which Plots 1 to 18 were situated had been broken up from old poor pasture 3 or 4 years before the experiment began; Plots 19 to 24 were on ground that had been a few years longer under cultivation. Where the plots begin the soil is slightly lighter and contains more peat than where they terminate, but the difference is very slight. When the oat crop was inspected in July, it was observed that the corn on Plots 15, 16 and 18 was somewhat injured by deep furrows, but otherwise the crops were regular, and, on the whole, the field is uniform and is well adapted for experimental purposes. When the pasture was broken up it was not worth more than 7s. 6d. per acre, and the first oat crop was a failure.

The scheme of manuring and the complete results, so far as available, will be found in Table VI.

Unfortunately the root crop on Plots 1-15 was entirely destroyed by wireworm and rooks, and as a consequence, the result of the treatment can only be given for four crops. For the purpose of comparison the Table gives separately the value of four crops on all of the Plots, and also the value of the five crops grown on Plots 16-24.

The Unmanured Plot.—

The crops obtained have been good on the whole, and the last oat crop was quite remarkable. Although very short in the straw the grain yield was 57 bushels per acre. The condition of the soil was due to the fact that it was recently a pasture. This must be remembered in studying the results, for it partly explains the action of the artificial dressings and the comparatively poor returns obtained from Dung.

Farmyard Manure.—

The effects on the hay and corn crops of the four dressings of Dung applied to the swedes are shewn in the diagram on page 51, and in greater detail in Table VI. A dressing of 6 tons of Dung applied to the roots has not increased the subsequent crops. Where 9 and 12 tons of Farmyard manure have been used the corn crops have been considerably benefited, and there has been a profitable return per ton of manure; but the use of more than 12 tons per acre for the swedes has not

DIAGRAM III.—ROSE BANK ROTATION.

Diagram illustrating the effects of:—

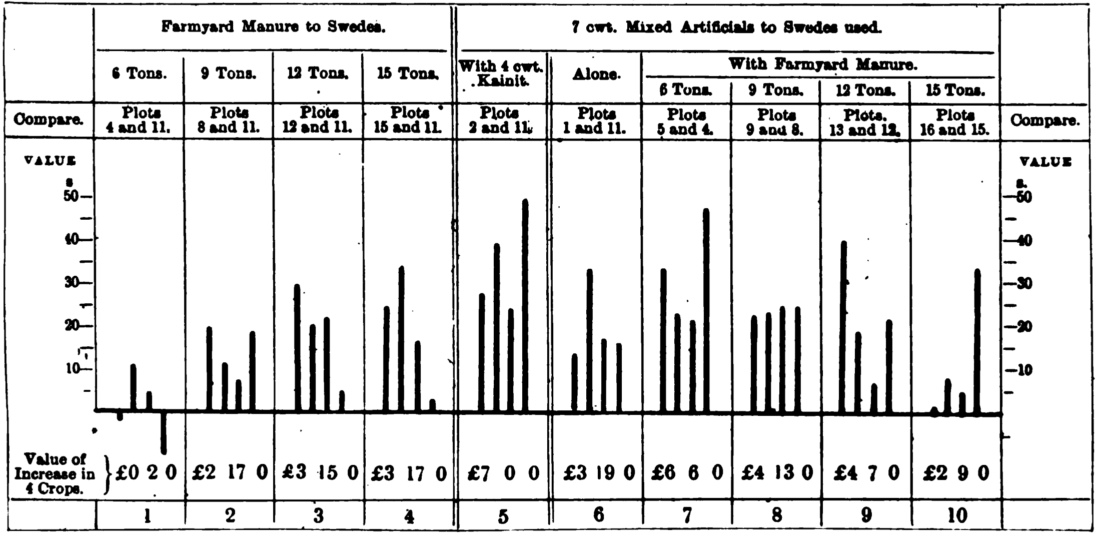
(1) using increasing quantities of Farmyard Manure (compare columns 1-4).

(2) using 7 cwt. Mixed Artificials alone (column 6); with 4 cwt. Kainit (column 5); and with Farmyard Manure (columns 7-10).

The 7 cwt. Artificials consisted of 2 cwt. Bone Meal, 2 cwt. Dissolved Bones, 1½ cwt. Superphosphate, 1 cwt. Fish Meal, and 1½ cwt. Sulphate of Ammonia.

The four lines in each column represent the INCREASED VALUE IN SHILLINGS per acre produced by the manures in the Oat, Hay, Hay and Oat Crops, respectively. *N.B.*—All the Manures were applied to the Root Crop, but as this crop was destroyed by rooks the effects of the manurial treatment can only be shown on the subsequent crops.

FIGURES PER ACRE.



* Decrease.

been justified by the results. It has been shown that at Kimblesworth, artificial manures might be dispensed with if a full supply of Dung were available; at Rose Bank, on the other hand, the inference from the four plots receiving different dressings of Farmyard manure is that purchased manures are necessary, and that it would not be economical to attempt to farm without them.

Artificial Manures.—

The 7 cwt. of "mixed artificials" used on Plot 1, and on the majority of the other plots, consisted of 2 cwt. Bone Meal, 2 cwt. Dissolved Bones, 1½ cwt. Superphosphate, 1 cwt. Fish Meal and ½ cwt. Sulphate of Ammonia. The mixture contained approximately 4·3 per cent. of Nitrogen, and 33·6 per cent. of Phosphate of Lime and the cost was about 39s. per acre. As an addition to this mixed dressing, 4 cwt. of Kainit was employed on certain of the plots; the cost of the larger artificial dressing was 48s. per acre, and the composition 2·8 per cent. of Nitrogen, 21·5 per cent. of Phosphate of Lime and 4·5 per cent. of Potash.

The increased value of the crops grown with Artificials is shown on the right half of the diagram on p. 51. It is interesting to notice that at Rose Bank they have proved on the whole much more profitable than Dung, even when it is their *after effects only* which are being taken into account. If Dung be assumed to cost 5s. per ton, the highest profit made by its use in this case was 15s. per acre (compare Plots 12 and 11). On the other hand the use of the artificial manures has in different cases left profits of 92s., 40s., 87s., 54s., 48s. and 10s. per acre. Artificials have done least when employed to supplement 15 tons of Dung, and they have relatively done best when used alone, or with a small dressing of Dung.

By comparing the results on Plots 1 and 2, it will be seen that if Artificials are used without Dung, the mixture must contain Potash; 9s. worth of Kainit applied for roots increased the value of the four following crops by a total of 61s. per acre. The smaller dressing of Artificials, containing no Potash, has done as well as the larger when used along with Dung. Apparently from 6 to 12 tons of Farmyard manure has supplied all the Potash required by the crops.

The beneficial action of the Dung at Rose Bank would almost appear to be limited to its effects as a potash manure, for if we compare the values of the crops grown, we find that 4 cwt. of Kainit has practically produced as great an effect as the bulky organic manure, thus:—

Plot 1,	7	cwt.	Artificials	only, produced 4 crops worth ...	£25 4s.	per	acre.
„ 2,	7	„	„	and 4 cwt. Kainit, 4 crops worth	£28 5s.	„	„
„ 5,	7	„	„	and 6 tons Dung, 4 crops worth	£27 13s.	„	„
„ 9,	7	„	„	and 9 tons Dung, 4 crops worth	£28 15s.	„	„
„ 13,	7	„	„	and 12 tons Dung, 4 crops worth	£29 7s.	„	„

In this soil we have, apparently, a case in which the mechanical effects of Dung are of no particular value, and it is therefore instructive to observe that we find no evidence of the superior value of Dung as a "lasting" manure.* In 1900 the best oat crop (except one) on the field was grown on land that had received no manures since 1896, and then only a dressing of Artificials. In the month of July, when the plots were visited, the superiority of Plot 2 over the dunged plots, and also of those plots that had received Dung and Artificials over the adjacent plots receiving Dung only, was most striking. So far from Artificials showing any tendency to exhaust the soil, it was evident that it was to their use and not to the Dung that the high condition of the land was due.

The diagram given on p. 51 is intended to show how each of the crops has been affected by the manurial treatment. It is curious that the increase produced by Potash, whether supplied in Kainit or in Dung, is much more marked on the corn crops than on the hay. It is difficult to account for the very heavy oat crops on Plots 2 and 5 last season, other than by the theory that the clover may have been stronger on Plots 2 and 5 than on 1 and 11, but of this there is no record. Another point brought out by the diagram is, that in every case, except one, there is a larger increase in the second corn crop than in the first. This is partly due to the fine crop with which the rotation closed; but the season was equally favourable to all the plots, and the difference shows that directly or indirectly (through crop residues) the manures applied in 1896 are still at work.

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* We have here another illustration of the fact that the value of a manurial residue depends chiefly upon the soil to which the manure has been applied (compare p. 79).

Should all the Artificials be applied to the Root Crop?

This most important question has been dealt with in nine rotation experiments. It will be convenient to refer to the results of several of them here. It has already been pointed out (p. 13) that experiments made on the root crop in seasons 1892 to 1895 proved that artificial manures, when used along with Dung, seldom left a direct profit. This led Dr. Somerville to plan a number of rotation experiments, the principal object in four at least of them being "to determine whether the prevailing system of applying all the manure—Farmyard and artificial—to the root crop, is on the whole the best that can be devised, or whether it will not prove better to apply less manure to the roots and more to the succeeding crops than has hitherto usually been the case. There is always some good reason—if it can only be found—underlying an old-established agricultural custom, but it does seem irrational to give one crop practically everything and the next four or five crops practically nothing."*

The question, again to quote Dr. Somerville,† is, "Is it better to put the artificial manures into the land for the turnips and allow the soil to take charge of them for the use of the barley, seeds, etc., that are to follow, or should we keep the manures in the bags, and take out and apply just as much as we think is wanted when the various crops are occupying or about to occupy the land?"

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* *Annual Report for Season 1895,* p. 80.

† *Ibid.* p. 81.

Of eight* rotation experiments, begun in the years 1895-97, seven have now been completed, and the outcome of thirty-three trials of the two systems is that in *one* the results were equal, in *nine cases* the best crops were got when the artificial manure was distributed over the rotation, and in *twenty-three cases* the crops were best when all the manure was applied to the root crop. If the average result of these trials be taken it will be found that the difference is not striking, it amounts to about 3s. per acre per annum in favour of the common method. But in order to appreciate the lessons taught by these important experiments the details must be studied, for in this case "averaging" merely hides the truth. In order to enable the reader to follow the details, diagrams have been prepared which show the chief results at Grange Hill, Ravensworth and Rose Bank, the three stations at which greatest attention was given to this problem. The case of Kimblesworth has already been alluded to.

The diagram on p. 56 illustrates the results of the rotation experiment at Grange Hill, which finished in 1898. The rotation consisted of four crops, swedes, barley, seeds and oats. Ten ¼-acre plots received 12 tons of Dung per acre for the swedes; to five of these, five different artificial manures were applied along with the Dung, on the other five plots the same Artificials were given to the barley, hay and oats, one-third to each crop. The Artificials used were in all cases essentially phosphatic manures. They contained about 38 per cent. of Phosphate of Lime and 2·6 per cent. of Nitrogen. The kinds and quantities applied are mentioned on the diagram.

On a sixth plot, No. 13, the manures used were the same as on Plot 12, but instead of giving one-third to each of the last three crops of the rotation, one-fourth was applied to each of the four crops.

The diagram compares the results of the two systems of using the manure thus:—The four lines in each plot repre-

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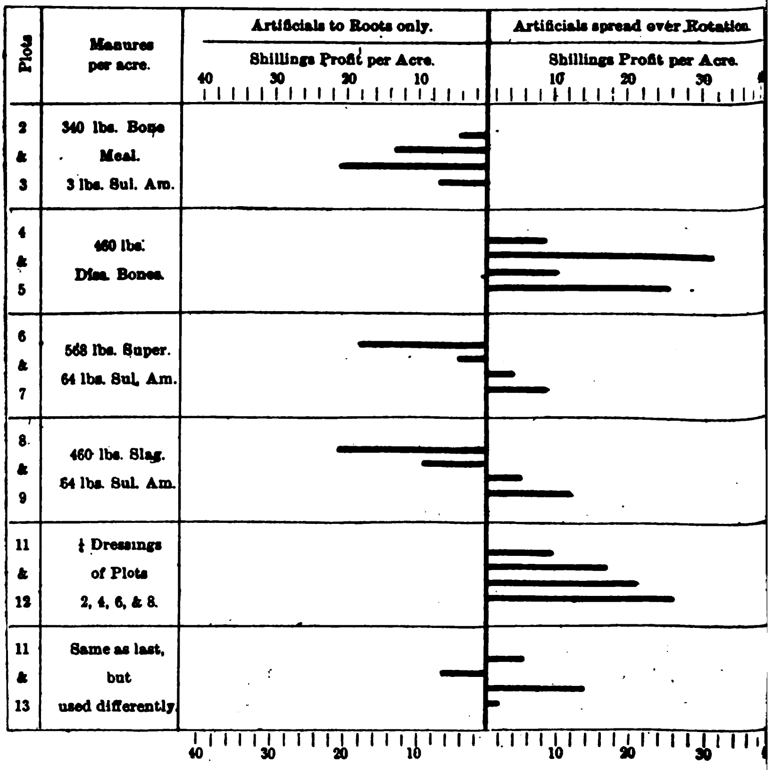
* This does not include the small Rotation Experiment at Barnard Castle School (see p. 68).

DIAGRAM IV.—GRANGE HILL ROTATION.

Diagram showing the relative advantages of applying all the Artificials to the Root crop, or of spreading them over the Rotation.

The length and position (right or left of centre) of the lines in the diagram indicate with which method the advantage is, in the case of Swedes (top line in each plot), Barley, Hay and Oats respectively.

On Plots 2, 4, 6, 8 and 11 all the Artificials have been applied to the Roots, on Plots 3, 5, 7, 9 and 12 the Artificials have been divided equally between the last three crops, on plot 13 equally between the 4 crops.



sent the four crops grown on it, the top line the swedes, next the barley, hay, and oats in turn. The corresponding crops of each of the pairs of plots are compared, and the amount by which the better exceeds the worse is shown by the length of the line, which is drawn to a scale that represents shillings per acre. The position of this line right or left of the centre shows whether it has paid best to spread the manure, or to apply it all to the roots. For example all four lines, in the case of the first pair of plots, point to the left. This means that when Bone Meal was used, every crop was best on that plot which received the Artificials for the swedes. In the next case it is just the reverse; that is, with Dissolved Bones it has paid best to spread the Artificials over the rotation. The four lines show that the advantage amounts to 8s., 31s., 10s. and 25s. for the root, barley, hay, and oat crops, respectively.

It will be seen that in general, spreading the Artificials has been most profitable on the "moderately strong but not deep" soil* of Grange Hill; but except on Plots 5 and 12 there is no marked superiority, and these plots must be admitted to be naturally better than Plots 4 and 11, for the swede crops on the former, which were grown with Dung alone, were better than those on the latter, grown with Dung and Artificials. The condition of the soil on the plots contrasted may be gathered from the weight of the root crop grown on each. Seven plots received Dung alone, the crops grown on them and on five plots which received Dung and Artificials were:—

Dung alone.		
Plot 3	16 tons	3 cwt.
„ 5	18 „	2 „
„ 7	16 „	2 „
„ 9	18 „	12 „
„ 12	18 „	0 „
„ 17	17 „	2 „
„ 21	17 „	17¼ „

Dung and Artificials.		
Plot 2	16 tons	13 cwt.
„ 4	17 „	2
„ 6	18 „	8 „
„ 8	21 „	5½ „
„ 11	16 „	17 „

It will be noticed that Plot 9 was distinctly above the average, but so was Plot 8 with which it compared. Plots 5

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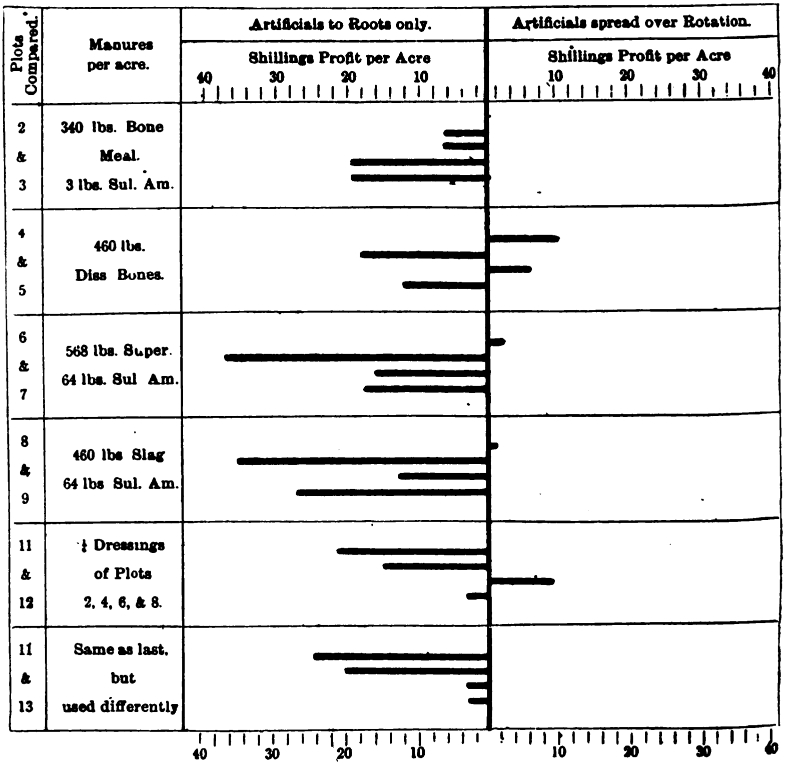
* For the chemical composition of Grange Hill soil see p. 230.

DIAGRAM V.—RAVENSWORTH ROTATION.

Diagram showing the relative advantages of applying all the Artificials to the Root crop, or of spreading them over the Rotation.

The length and position (right or left of centre) of the lines in the diagram indicate with which method the advantage is, in the case of Swedes (top line in each plot), Oats, Hay and Hay respectively.

On Plots 2, 4, 6, 8 and 11 all the Artificials have been applied to the Roots, on Plots 3, 5, 7, 9, and 12 the Artificials have been divided equally between the last three crops, on plot 13 equally between the 4 crops.



and 12 were also above the average, whilst Plots 4 and 11 were not.

The rotation experiment made at Grange Hill was repeated at Ravensworth on a strong, well-drained clay soil in rather low condition. The only difference between the two experiments was that in the latter, the second crop was oats, and the fourth, and final crop, hay.

At Ravensworth (see diagram, p. 58) the results were almost uniformly in favour of the system of using the Artificial for the root crop, and one of the few exceptions (the root crop, on Plots 4 and 5) tells rather in favour of the system than against it, by showing that the soil of the latter was naturally better than that of the former. It is probable that if this rotation had finished up with a corn crop, instead of with hay, the "top-dressings" would have yielded better returns, but it is unlikely that any change in the crop would have materially affected the results.

At Rose Bank sixteen of the twenty-four plots were designed to afford information on the question now under discussion, and the results of ten have been brought together in the diagram on p. 60. The general plan was the same as in the Grange Hill and Ravensworth rotations; but at Rose Bank the effects of using the same artificial manure* in conjunction with varying quantities of Dung have been tested, at the other stations, the quantity of Dung was constant and the character of the artificial mixtures varied; further in the Cumberland experiment, the Artificials, where spread, were equally spread over all five crops.

The Rose Bank results, like those at Ravensworth, are almost invariably favourable to the older system of using artificial manures. This is remarkable, for on most of the plots the loss of the swede crop has made it necessary to compare the effects of the residue of an artificial mixture, with the effects of fresh applications. On two only of the plots referred to in

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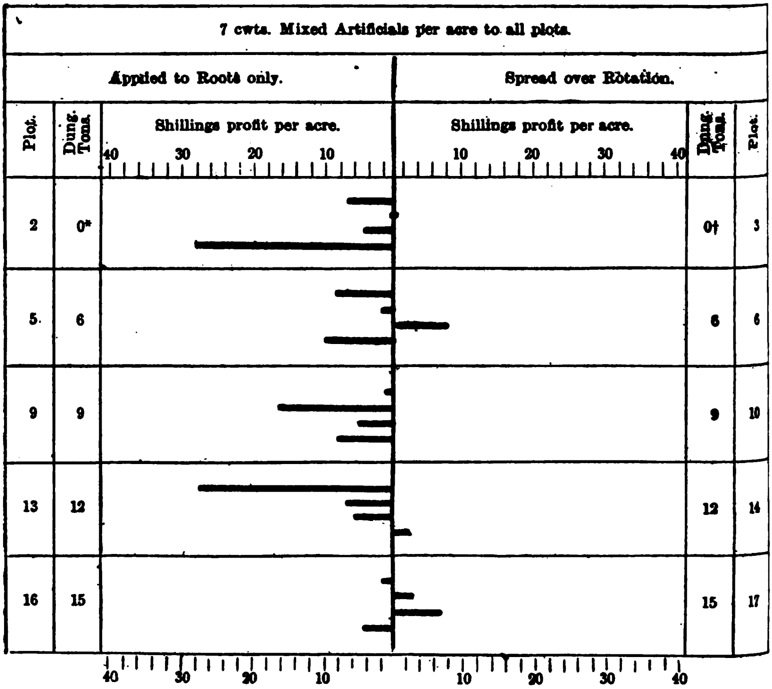
* The "mixed artificials," used on the plots getting dung, contained 33·6 per cent. Phosphate of Lime and 4·3 per cent. Nitrogen.

DIAGRAM VI.—ROSE BANK ROTATION.

Diagram showing the relative advantages of applying all the Artificials to the Root crop *or* of spreading them over the Rotation.

The length and position (right or left of the centre) of the lines on the diagram indicate with which method the advantage rests in the case of the Oat (top line in each plot), Hay, Hay and Oat crops, respectively.

Where spread, the Artificials have been equally distributed, except on Plot 3, where 5 cwt. have been applied to the Roots.



* 4 cwt. Kainit to Roots.

† 2 cwt. Kainit to Roots, and 2 cwt. to Hay Crops.

the diagram, were swedes grown, and then it was found that 7 cwt. of Artificials benefited the crop very considerably. It is probable that there would have been a similar benefit on the other plots, and accordingly greater profits than have been placed to the credit of Plots 2, 5, 9 and 13, if wireworms and rooks had not appeared to supply one argument at least in favour of keeping the manure in the bags.

If Table VI. be referred to it will be seen that the other results at Rose Bank are in general accordance with those shown in the diagram. On Plots 22, 23 and 24, 7 cwt. of artificial manures were applied (1) equally to the last four crops; (2) half to roots and half spread over the three last crops; and (3) all to the last three crops of the rotation, but in no case was the value of the produce so great as when the manure was all applied to the swede crop. The one case, in which spreading the artificial manure paid, was when very heavy dressings were used. Plot 19 received 14 cwt. of artificial manure with 12 tons Dung for the swedes, and produced crops worth £35 15s. Plot 20 got 7 cwt. for the swedes and 7 cwt. equally distributed over the hay and cereals and the crops were worth £39 5s.; and Plot 21 received 14 cwt. equally applied to all five crops and grew produce worth £37 13s. It may be pointed out that the four crops grown on Plot 13 were worth as much as the four corresponding crops of Plot 20, and worth a good deal more than the corresponding crops of Plot 19.

The soil of Plot 19 was apparently quite equal to the rest of the field and it is difficult to give a reason for the inferior crop. It is possibly due to the fact that the artificial mixture contained no Potash. Or perhaps the application was more than was good for the land. Doubling the artificial dressing at Ravensworth, had the same effect as here. The gross produce was worth less than where a moderate dressing had been used.

The figures obtained from the rotation experiment at Cockle Park (Table XXII.) are in accordance with Rose Bank results. Where 14 cwt. of Artificials were used without Dung (Plots 11 and 14) it paid best to spread them over the rotation; but where 7 cwt. of Artificials were used with Dung (Plots 16, 19, 20, 21) it has proved better to apply all to the root crop. At Ravenglass and Woodend, in Cumberland, where 12 cwt. of Artificials were employed without Dung, the two methods of using the manure proved to be practically equal. (See Report for 1899, Table XXV.).

The conclusion to which these numerous trials lead, is that it is usually best to apply to the root crop phosphatic manures such as Superphosphate and Basic Slag, or manures that are chiefly phosphatic, as Bone Meal. We have not sufficient evidence to justify a conclusion regarding potash manures, but the indications of both the Rose Bank and the Kimblesworth experiments are that the greater part of the Potash should be applied to the root crop. Except at Cockle Park we have seldom found potash manures beneficial as top-dressings on arable land. On the other hand their great value when employed for the root crop has frequently been shown.

As regards the use of common nitrogenous manures, there is no question that in ordinary seasons on many farms and in some seasons on all farms, top-dressings of Sulphate of Ammonia or of Nitrate of Soda will pay. At Grange Hill, for example, the liberal use of Nitrate resulted in a net profit of £4 per acre in four years, and similarly at Cockle Park the use of 1 cwt. of Sulphate for each of the two cereal crops left a profit of £2 13s. per acre (see Plots 12 and 13, Table XXII.). At Ravensworth and Kimblesworth, on the other hand, top-dressings of Nitrate on the one, and of Sulphate on the other farm, just about repaid their cost.

Theory and experience agree that nitrogenous manures are safer "in the bag" than in the ground, until the crop which they are to benefit occupies the soil, but theory and experience do not agree when phosphatic manures are in question. Despite all discrepancies due to soil and the "uncontrollable conditions" that vex the experimenter, there can be but one conclusion from these seven rotation experiments. The evidence, though seldom striking, is cumulative; in by far the greater number of cases, crop after crop gives its testimony in favour of the soil as a store-house, and, irrational though the conclusion may appear, both our experiments and "old established agricultural custom" agree that it is usually better to apply our Phosphates "to the turnip crop and allow the soil to take charge of them" than to "keep the manures in the bags and take out and apply them" as they are wanted for the hay crops and cereals.

The "theory" of the subject is apparently simple and straight-forward and is entirely in favour of the less successful of the two practical measures.

It is this:—(1) Plants require soluble Phosphates for the production of tissue (that is as food); (2) phosphatic manures (which, when applied to the soil, are all in a comparatively soluble state) are not subject to losses from drainage, as for example Nitrates are, but they are liable to form very insoluble compounds which cannot easily be decomposed by the roots of plants, and which are believed to be of little use as plant food. This being the case, it is surely reasonable to apply, a readily soluble manure, such as Superphosphate to the crop which requires it. When an insoluble manure, such as Slag or Bone Meal is applied in the drill it is more thoroughly mixed with the soil than when applied as a top-dressing to subsequent crops, and it is possible that this may account in part for the advantage of using such manures for the root crop (see Report for 1889, p. 79). But thorough admixture does not account for the action of soluble manures, and assuming that the sole function of the Phosphate in the soil is to supply food, it is very difficult to give any explanation that will reconcile the theoretical and practical aspects of this question. It is possible, however, that the supply of phosphatic compounds to the cultivated plant is not the sole function of Phosphates. The development of micro-organisms, like the growth of the green plant, is dependent on a supply of mineral matter, and it is quite conceivable that the decomposition of Dung or of crop residues may be more or less favourable to a fertile condition of the soil, according as the supply of mineral manures is abundant or otherwise. One circumstance favouring the view that Phosphates are indirectly, as well as directly, useful to plants, is the fact that although these manures are highly profitable from the commercial point of view, they must be employed in what is apparently an extravagant fashion. When we use Nitrate of Soda we expect to recover 50 to 80 per cent. of the manure in the increased crop; but of the Phosphates applied to the soil in ordinary farming we seldom recover more than from 10 to 20 per cent. Is the profit which attends the use of the phosphatic manure altogether due to the very small percentage that the cultivated plant takes up, and uses as food?

There is another aspect of this subject that may be referred to. Artificial manures influence the texture and water-holding capacity of soils, and although useful in supplying food, they may at times unfavourably affect the welfare of the crop. But so far as the experiments at Rose Bank are concerned, we have no record of any such injury, and it is unlikely that the results have been affected by any unfavourable physical action on the part of the moderate dressings that have been used.

Summary.—

A rotation experiment was carried out on a poor moorland soil at Rose Bank, near Dalston, in Cumberland, the soil was recently broken up from pasture, valued at 7s. 6d. per acre. The crops were swedes, oats, hay, hay, oats. The first crop on most of the plots was destroyed, but the others were good. The experiment contained 24 ¼-acre plots. A summary of the results is given and a reference to the results of similar experiments.

(1) An organic manure was not necessary to improve the texture of the soil and Farmyard manure proved much less

effective than Artificials. In this respect the results at Rose Bank and Kimblesworth were widely different. These two experiments illustrate the conditions under which, on the one hand, Artificials, and on the other, Dung, may be profitably employed in arable farming.

(2) On a suitable soil Artificial manures proved lasting in their effects. In 1900 the second best oat crop among twenty-four, was grown on Plot 2. This plot received 11 cwt. of Artificials in 1896, no Dung, and nothing afterwards.

(3) In the absence of Farmyard manure, Kainit greatly benefited the crops. Its effects were more apparent on the corn crops than on the hay.

(4) In seven rotation experiments, the question as to whether it is better to apply all the artificial manures to the roots or to spread them over the rotation has been tested thirty-three times, in *twenty-three* cases it has proved better to apply them to the roots. It should be noted that the manures used were mainly phosphatic in character. Details will be found in diagrams, see pp. 56-60. At Rose Bank the results derive special importance from the fact that the soil responded readily to the action of artificial manures. In this case, too, we compare the effects produced by *the residues only* of artificial manures, with the effects of *fresh applications*, for, in most instances, the swede crop was destroyed.

ROTATION EXPERIMENTS AT PEEPY AND WHITEFIELD, NORTHUMBERLAND.

The crop grown at these stations during the past season was rye-grass and clover hay. This was the third crop of the second rotation, and the seventh of the experiment. The oat crop of 1901 will complete the second rotation, and a full report will then be published. Some of the leading features of the hay crop will be briefly noticed here. The season was a favourable one for hay, the crops at both farms being exceedingly good. The actual differences in weight (see Table VII.) between the different plots were small, considering the very different treatment which the land has had; but the differences in the appearance of the plots and in the proportions of rye-grass and clover were in many instances very striking. On both farms, omitting the Dung greatly reduced the percentage of clover. At Whitefield, more especially, the absence of clover on Plot 10 (no manure) and the poverty of the plant on Plot 20 (Corporation manure) were very noticeable. The application of six tons of Dung in the autumn of 1899 was markedly beneficial at Whitefield, and at Peepy the promise of the crop was also exceedingly good; but as it consisted largely of clover it weighed very badly as compared with the majority of the plots, and the yield of the first "cut" of hay was less than on plots that appeared to be much inferior.

The effects of phosphatic and potassic top-dressings were scarcely noticeable at either station. At Peepy the heavy dressing of Kainit applied to the root crop improved the appearance of the clover plant, but not the weight of the hay crop.

The second crops at Peepy were very fair. The aftermath of Plot 5 looked especially vigorous, and contrasted strongly with the poor crop on the adjoining Plot 6. On the unmanured plot the aftermath was almost entirely rye-grass.

At Whitefield there was very little aftermath. The only plot that looked at all healthy was No. 5, and here, as at Peepy, the effects of the Dung applied in the previous autumn were marked. Here, too, there was a sharp contrast between Plots 5 and 6. The result of an insufficient application of Dung to the root crop was severely felt by the clover crop at both stations. The unmanured land appeared to be completely exhausted, and upon it there was almost no aftermath. The aftermath on Plot 18, which received Farmyard manure, looked much stronger than the second growth on either Plots 19 or 20 (Horse Dung and Corporation manure). Both the first and second hay crops showed plainly that the clover plant finds Corporation manure a very poor substitute for ordinary Dung.

ROTATION EXPERIMENT AT THE N.E. COUNTIES' SCHOOL, BARNARD CASTLE.

This experiment on a four-course rotation finished with the crop of 1900. Previous notices of the work have appeared in the Annual Reports of the Agricultural Department of the College for 1897 and 1899 (see pp. 49 and 81, respectively).

The soil, a strong, dark loam resting on clay, was broken up from old pasture in the winter of 1895-96, and divided into 9 $\frac{1}{16}$-acre plots. The crops were to have been potatoes, beans, oats and vetches, but the oat plant was destroyed by birds in the early summer, and white turnips formed the crop of 1899.

The objects of the experiment were educational and the scheme was very simple. The manures applied and the full results will be found in Table VIII.

The vetch crop of 1900 was a moderate one, the best yield was 33½ cwt. on Plot 7. The small dressing of Artificials proved to be a considerable assistance. It is remarkable that the Dung applied to Plot 3 in 1899 should have been of so little use to the vetch crop in 1900, and it will be noticed that neither of the "Dung" plots has done well. From the results of the first two seasons it may be inferred that Plot 2 was naturally one of the best, and the poverty of the vetch crop must have been due either to the disappearance of the manurial residue of the Dung, or, as is much more likely, to an inferior condition of the soil brought about by a failure of the previous crop. A good crop of turnips, or a bare fallow, may, either of them, leave land in good condition, on the other hand a crop of 7 tons of turnips is likely to leave the soil in anything but good condition. Remarks have already been published on the individual crops and, as the plots were small and some of the crops failed, it will be safer not to draw any conclusion from the general results.

In reading through Table VIII. it will be noticed that the question of the time for applying Artificials was tested on four plots, and as in most of the other trials application to the fallow has paid best. The returns from the potato crop were, however, very erratic, and if we exclude them, and compare the returns from the three subsequent crops, we find that the figures are not so favourable to this system. The later crops were better where the Artificials were spread. In the circumstances it could hardly have been otherwise.

It will also be observed that the very heavy application of Artificials applied to Plot 8 appeared to lower the yield of the potato crop, and in spite of its beneficial action on the beans which followed, it has actually reduced the gross returns by nearly £2 per acre. This may be accidental and would not have been worth notice, were it not that it corresponds with the results got at Ravensworth and Rose Bank.

The most interesting point in connection with the Barnard Castle experiment was the effect produced on the bean crop of 1898 by the omission of Dung. On Plot 8, which in the previous season received 12 tons of Dung and a heavy dressing of Artificials, there was a crop of 37 bushels of beans; on Plot 9, where the potatoes had received the same Artificials but no Dung, the bean crop was only 11½ bushels.*

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* The failure of the bean crop was probably due to the lack of available nitrogen. Where Dung had been employed in the previous season the supply of nitrogenous food would be enough to support the young bean plants until the root organisms made them independent of soil nitrogen. But the Artificials used for the potatoes on Plot 9 would have disappeared before the spring of 1898. It is a mistake to suppose that, because in the later stages of its life a bean plant may become independent of soil nitrogen, that it is independent at all times.

In a case (at Aberystwyth) where beans were grown after potatoes on land recently broken up from pasture the young plants were found to be greatly injured by the absence of soluble nitrogenous manures. On land abundantly supplied with Phosphates and Potash, but without Nitrogen, scarcely a plant developed root nodules. The few that did appear came late in the season (middle of July), and the crop was a failure. Where a complete artificial manure was used, nodules formed very abundantly in June and the crop was a fine one.

EXPERIMENTS ON OLD LAND HAY.

In the following Table the names and other particulars are given respecting the stations on which Old Land Hay experiments were carried out in season 1900.

Name of Station.	Occupier.	Date of Commencement of Experiment.	No. of Plots.	Total Area.	No. of Table, giving details.
				acres.	
CUMBERLAND, SET I.					
Blencow	Mr. M. Walker ...	1895	16	¾	IX.
Castle Carrock ...	Mr. J. W. Steele ...	,,	,,	,,	
Eskdale	Mr. T. Troughton ...	,,	,,	,,	
Glasson	Mr. G. Graham ...	,,	,,	,,	
CUMBERLAND, SET II.					
Brampton	Mr. J. P. Johnson ...	1895	16	¾	X.
Gosforth	Dr. Parker	,,	,,	,,	
Kirkbampton ...	Mr. J. Holliday ...	,,	,,	,,	
Wigton	Mr. H. W. Pallister	,,	,,	,,	
DURHAM.					
Seaham	Messrs. The Seaham Harbour Stud Co.	1894	20	1	XI.
Shield Ash	Mr. J. Robinson ...	1896	16	⅘	XII.
NORTHUMBERLAND.					
Broomhaugh ...	Mr. C. Marshall ...	1893	20	½	XIII.
Palace Leas, Cockle Park	County Council ...	1896	26	9	XXVII.

A systematic account of these experiments has been given in the Reports already issued by Dr. Somerville, and it will not be necessary to refer to the figures of the present year in detail. So far as the profits are concerned it may be stated that, with an exception referred to on p. 74 the conclusions of the earlier years are being confirmed. The interest now centres not so much in the money returns, as in the gradual changes in soil and herbage which are being brought about by the action of certain of the manures.

The changes in the character of the herbage of the Cumberland stations was the subject of an article by Dr. Somerville in Vol. VII., No. 3, of the *Journal of the Board of Agriculture*, which has been reprinted by permission (see p. 84). Some further gradual changes, and some of the lessons taught by the comparison of last season's results with those of former years will now be noticed.

Effects of Season.—

The hay crops of season 1900 were satisfactory, and, with the exception of 1898, better than in any of the past five years. The average produce of the unmanured and best plots at eleven stations in each of the five years ending 1900, was as follows:—

Year.	Unmanured Plot. Cwt.	Best Plot. Cwt.
1896	18½	30¼
1897	19	35
1898	27	45¾
1899	22½	36
1900	22	42
Average of 5 seasons	21⅘	37⅘

The following table will be of interest as showing the influence of season on the hay crop in different localities. It gives the produce per acre of the unmanured and the best plot on four stations situated in a line stretching across England from sea to sea. Shield Ash, near Stanhope, and Castle Carrock, near Brampton, are inland stations. Seaham and Eskdale are both close to the sea, the one on the east, the other on the west coast.

Station.	1896.		1897.		1898.		1899.		1900.	
	Unmanured Plot.	est Plot.	Unmanured Plot.	Best Plot.	Unmanured Plot.	Best Plot.	Unmanur.d Plot.	Best Plot.	Unmanured Plot.	Best Plot.
	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
Sealiam	23	41	10¼	21	38	54½	24	37	17½	39½
Shield Ash ...	20¼	32½	22½	37	24¾	54¾	24¼	50¼	23¾	50½
Castle Carrock ...	15	31	22¼	46¼	30¾	46	22	39½	21	48
Eskdale	14¼	34¾	17¼	41½	16¼	33¼	27	48½	22¾	45½

Two Classes of Grass Land.—

So far as the North of England is concerned, the land devoted to the growth of hay may be divided into two classes, viz., land that is *not*, and land that *is* greatly benefited by the application of slag.

When land is not benefited by slag, or is only moderately improved by its use, our experiments indicate that complex manures* should be used, that they should be used in small or medium dressings, and that they should be applied frequently. Heavy applications at an interval of years cannot be recommended. A stunted plant, like a starved animal, is unable to assimilate much food, and it may prove as wasteful to manure a poor meadow heavily, as to feed lean hide-bound cattle on full rations of cake and meal. The herbage of the meadow, and the digestive organs of the beast, should be gradually accustomed to liberal fare.

But, when land is markedly improved by Slag, as in the case of the soils at Cockle Park, then the best practice would seem to be to manure heavily and occasionally. This, at least, has been our experience in the Tree Field (see p. 134). Nor, in this case, is any complex manure required. As a first step in improving the herbage, Slag, and Slag alone, will often prove superior to any mixture that can be compounded.

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* See footnote, page 44.

The Action of Basic Slag.—

This difference in the treatment of the two classes of grass land may be explained by the action of Slag. This manure has a direct and an indirect effect on the pasture. Like Superphosphate and Dissolved Bones, it supplies Phosphates, and Phosphates benefit the majority of the plants that make up a hay crop; but to a greater extent than any other Phosphatic manure, Slag stimulates the growth of the clovers, and the advantage of using this substance on its own peculiar soil is due to the fact that it enables white clover to cover the ground before the grasses become strong enough to dispute the surface with it. In the "battle of the meadow" white clover is not a strong fighter, but when suitably aided it strikes quickly. It is when Slag enables clover to obtain a temporary mastery, that it becomes of peculiar value as a manure. The way in which clover ameliorates poor thin clay soil by opening it up and by bringing in supplies of plant food from the atmosphere, is alluded to on p. 136.

The clovers are very readily injured by acids or sourness in the soil, and this explains the superiority of Basic Slag over the acid soluble Phosphates as a food for clover. The botanical separations of the herbage for the first four seasons of the experiment on Tree Field, Cockle Park, admirably illustrate the different effects of acid and basic Phosphates on the development of white clover. The percentage of this plant found in the hay cut from four of the plots in each of the four seasons is shown in the following table.

Plot.	Treatment per Acre.	Percentage of White Clover in Herbage.			
		1897.	1898.	1899.	1900.
6	Unmanured	·1	·3	·2	·4
5	7 cwt. Super for 1897, and again for 1900 ...	1·1	·1	2·3	14·6
4	5 „ Basic Slag for 1897, and again for 1900...	2·4	15·6	6·8	22·1
3	10 „ „ „ „ *not* repeated ...	4·8	13·8	3·0	5·1

Why Slag Fails.—

Basic Slag of the highest quality is often found to be valueless, or comparatively valueless, on meadow land. On superior pastures, where white clover is unable to assert itself, Slag seldom proves effective; but even upon poor grass land, where it ought to work well, Slag is sometimes found to be a worthless and exhausting manure, because the soil is naturally deficient in Potash. When Slag fails for this reason, the fault is the farmer's; the manure would prove profitable if it were used with discretion. A great many of our poor pastures are, like those at Cockle Park, sufficiently supplied with Potash; but this is by no means always the case, and every farmer who uses Slag, and Slag only, without satisfying himself that Potash manures are unnecessary, runs a risk of wasting money, and may lose an opportunity of improving his land.

The results of the hay experiments at Broomhaugh bring this out very clearly. These experiments have now been in progress for eight years, the manures have been applied in every year but one (1895), and the results on four of the plots are depicted in the diagram on p. 75. The lines show the increase or decrease, as compared with the unmanured plot, in each of the eight seasons. The difference in the action of the two manures, Slag and Kainit, when used separately and together, is remarkable. By itself, Kainit has been worse than useless, and Slag, though profitable in the second year of the experiment, has since been of little value. But where these two substances were employed together, not only has there been a profitable increase, but a growing increase, and it is quite obvious that, as a result of suitable manuring, fertility is accumulating in the soil. It is interesting to compare the development of Plots 7 and 8. In the earlier years the complete manure was much the better, but gradually the clovers on Plot 7 have been storing up Nitrogen, and now the soil, well supplied with this substance, is much less dependent on the application of a nitrogenous manure. For soils, like those at Broomhaugh—which are benefited by Slag, and

DIAGRAM VII.—BROMHAUGH HAY EXPERIMENT—B.

Results for eight seasons, 1893-1900.

The eight lines, taken in order from left to right, show the increase or decrease as compared with the unmanured plot in each season.

The manures were applied yearly, except in 1895 (the third season).

The Diagram shows :—

1.—The poor effects of Slag and Kainit when used separately.

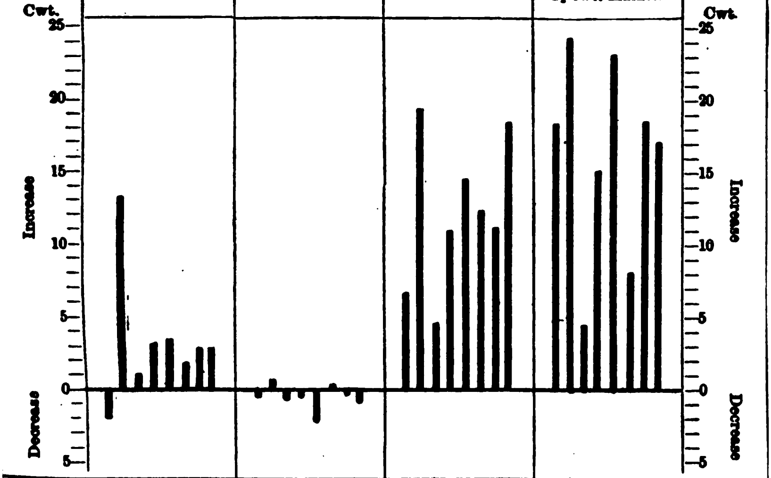
2.—The result of a combination.

3.—The tendency of this combination to make the soil independent of Nitrogenous Manures (compare plots 7 and 8).

The Hay has been valued at 50/- per ton.

FIGURES PER ACRE.

	Plot 3.	Plot 4.	Plot 7.	Plot 8.	
	3½ cwt. Slag.	2½ cwt. Kainit.	3½ cwt. Slag. 2½ cwt. Kainit.	1 cwt. Nit. of Soda. 3½ cwt. Slag. 2½ cwt. Kainit.	



	Plot 3.	Plot 4.	Plot 7.	Plot 8.	
Increase or Decrease (—) in 8 years	27 cwt.	– 4 cwt.	97 cwt.	129 cwt.	Increase or Decrease (—) in 8 years
Profit or Loss (—) in 8 years	£0 11 0	– £3 2 0	£6 16 0	£7 19 0	Profit or Loss (—) in 8 years

are deficient in Potash—Kainit, or Muriate of Potash, should be applied in the spring after Slag has been used, or a dressing of Dung may be given; but for poor soils the artificial manure is likely to be the more profitable. In many cases Slag and Farmyard manure make a good combination; for example, at Shield Ash, in Weardale (see Plots 12, 13 and 15, Table XII.); but on the poorest class of "Slag" soils it is well to avoid Dung at first, and to apply it two or three seasons after the Slag; it is apt to stimulate coarse grasses, to the detriment of the clovers, and, moreover, it will seldom pay to use Dung for this class of soil if the farmer possesses superior grass or tillage land upon which it may be used.

Cumulative Fertility.—

All through these hay experiments, wherever suitable manures have been employed, we find a general tendency towards the accumulation of fertility, so that the profits in the later years are greater than in the earlier. This has already been noticed in the case of Plot 7 at Broomhaugh. The diagram on p. 77 shows a similar tendency to increase in some of the other experiments. The variable character of the seasons has interfered with this upward movement, and in many individual cases prevents any conclusion being drawn for the short period of years for which we have records; but on the Shield Ash plots, and on the average of three of the Cumberland stations, a gradual improvement is shown.

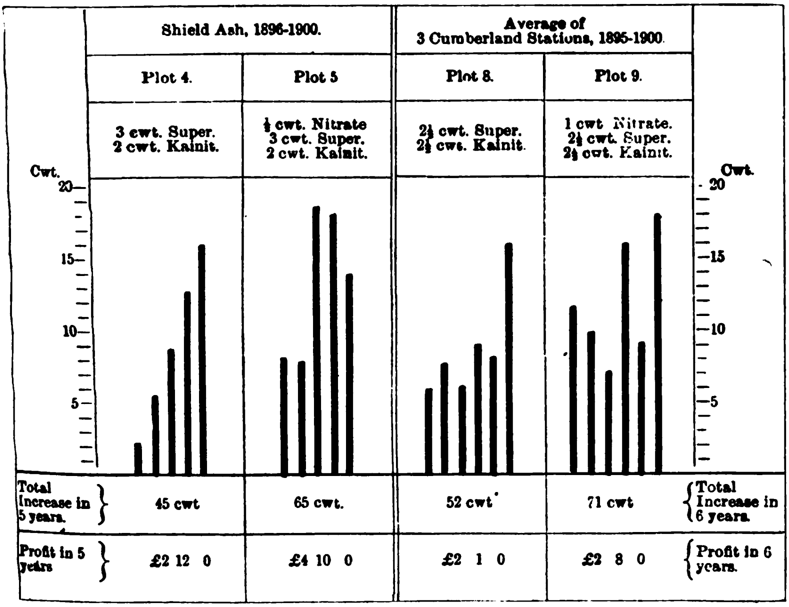
This diagram, like the last, further shows that where Phosphates and Potash have been employed the soil gradually becomes less dependent on nitrogenous manures. The continuous improvement of Plot 4 at Shield Ash is very striking, and in Cumberland, too, although there has been an accumulation of fertility on both of the plots, it has been greater on Plot 8 than on Plot 9.

DIAGRAM VIII.—HAY EXPERIMENTS IN DURHAM AND CUMBERLAND.

The lines in the Diagram, taken in order from left to right, show the increase over the unmanured plots produced in each of five years at Shield Ash, Weardale, and in each of six years at three Cumberland Stations* by annual applications of

1,—Super and Kainit.
2,—Nitrate, Super, and Kainit.
Compare Broomhaugh Experiment B. Plot 7 and 8.

FIGURES PER ACRE.



* Castle Carrock, Eskdale, and Glasson. In 1897 the hay at Glasson was not weighed and the average was that of two centres. The Blencow figures have been excluded as the soil of this station is not quite uniform.

The Residues of Artificial Manures.—

From what has been said, it follows that artificial manures must usually leave a residue for subsequent crops, but even when well-balanced mixtures are employed we do not always find that there is an effective residue.

The plots at three Cumberland centres (the three most reliable of ten which were started six years ago) were manured in 1895, 1897, 1898, and 1900, and left without manure in 1896 and 1899. The following table shows the average increase over the unmanured plot, in the first four, and in the two last-named seasons, on six plots which received "complete manures."

Plot.	Manuring.	Average INCREASE or DECREASE (−) compared with the Unmanured Plot at					
		Brampton.		Kirkbampton.		Gosforth.	
		Manure Applied.	Manure Withheld.	Manure Applied.	Manure Withheld.	Manure Applied.	Manure Withheld.
		Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
7	½ cwt. Nit. Soda ... 3½ „ Super. ... 3½ „ Kainit ...	11¾	4¼	10¾	3¼	8½	−2½
9	½ cwt. Nit. Soda ... 3 „ Slag ... 3½ „ Kainit ...	9½	3¼	10¼	5	9¼	−3¼
11	3 cwt. Dis. Bones 3½ „ Kainit ...	11	4½	8¼	3¼	11¼	1½
12	2¼ cwt. Bone Meal 3½ „ Kainit ...	8	2¾	9¾	3	9¾	−2
13	1 cwt. Fish Meal 2½ „ Slag ... 3½ „ Kainit ...	11	3¾	10¾	2¾	10¼	0
14	⅕ of collective dressings of above plots	14¼	5¾	17	5¾	13½	2¼
	Average of six plots ...	11	4	11	4	10½	−¾

There are several noticeable features in the figures in the above table. The first thing that strikes one is that "*residue*" *is a question of soil rather than of manure.* On the deep, moist soils of the two first stations, all the manures have had substantial after effects, whereas at Gosforth, on a dry, gravelly loam, neither the soluble nor the insoluble manures have done any good except in the seasons in which they were used. It will be further remarked that at Brampton and Kirkbampton the manure that left the greatest residue was the same manure that produced the best immediate results. At Brampton, the converse is also true—the smallest residue was left by the manure that gave the least assistance to the crop to which it was applied. This was the mixture of Bone Meal and Kainit. At none of the stations has Bone Meal shown any superiority over the soluble manures.

The effects of the different manures at each of the stations have, on the whole, been very similar, and the figures may therefore be "averaged" with confidence. The average result is that, both at Brampton and Kirkbampton, we have a "residue-value" equal to about *one-third* of the original increase. At Castle Carrock, Eskdale, and Cockle Park, where Dung was used for hay in alternate years, the residue produced, on the average, about *two-thirds* of the effect of the direct application.

The value of a mixed manure is very clearly shown in the foregoing table. At each of the stations Plot 14 was much the best. This, as has already been remarked, is our usual experience. For further instances see Table XI., Plots 17 and 18, and Table XII., Plot 11.

Effects of Manures on Meadow Herbage at Broomhaugh.—

A diagram (see p. 81) has been prepared to illustrate some interesting changes in the botanical composition of the herbage that have taken place on eight plots at Broomhaugh as the result of using various manures. These plots, which are situated within a few hundred yards of the Broomhaugh plots already referred to, were manured, in 1893 and 1894, in the manner shown in the diagram. In the latter year, samples of the herbage were taken, and the percentages of grass, clover,* and weeds were determined. Since 1894, the plots have received no manure of any kind, and hay has been cut in each season. In 1900, the hay was again sampled and separated as before.

In the diagram the upper line shows the percentage of clovers and clover-like plants present in 1894, and the lower line the percentage present in 1900. In the case of the unmanured plot the proportion of clovers has remained the same, but in some of the others there have been startling changes. It has already been remarked that, in the "battle of the meadow," white clover strikes quickly; it rapidly spreads over unoccupied ground, and its mobility secures for it temporary successes; but it is not a strong combatant, and it disappears if its supremacy is disputed. At Bromhaugh we have several illustrations of these characteristics. The most pronounced is on Plot 7. Here, under the influence of Slag and Kainit, the clovers increased from 8·1 to 29·2 per cent. in two years' time; but after the stimulus supplied by the manures was withdrawn, other plants took advantage of the stores of food accumulated, and at the end of six years the clovers on the plot had fallen to 4·7 per cent., or little more than half the amount present on the unmanured plot (see detailed figures in Table XIV.). That the clover was the cause of its own undoing is shown by the results on other plots. Almost in proportion to its former activity is its final subjection. The only plots on which clover was strong in 1894, and still held its own in 1900, were Nos. 4 and 5, and here it is very interesting to notice that the manures applied lacked Potash in the one, and Phosphates in the other case, so that the Nitrogen gathered by the clovers could not be taken advantage of by the grasses. Thus the leguminous plants have continued to occupy the soil not because of their own strength, but because of the feebleness of

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* With the clovers, trefoil and other *Leguminosæ* were included.

DIAGRAM IX.—BROOMHAUGH HAY EXPERIMENT—A.

The plots were manured in 1893 and 1894, and cut for hay; thereafter they were cut for hay each year but were not manured.

The herbage was separated into Grasses, Leguminous plants (chiefly white clover) and Weeds in 1894, and again in 1900.

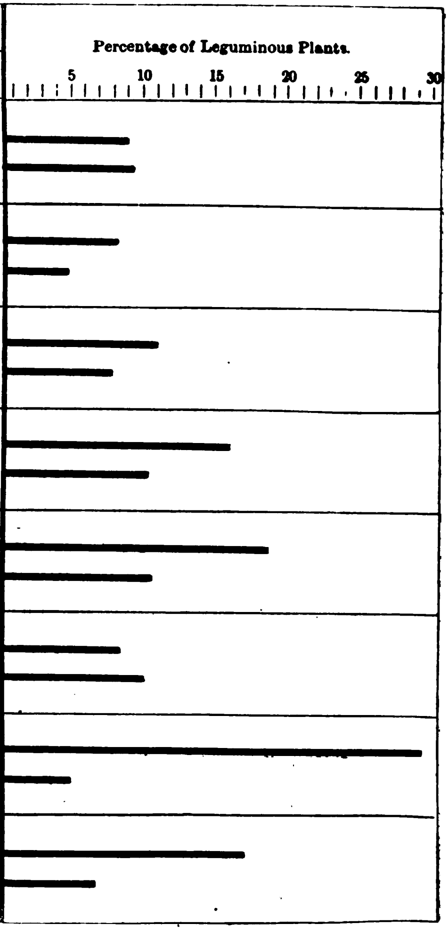
The lines in the diagram indicate the percentage of *Leguminosæ* present in each plot, and show:—

1.—The effects of manuring in 1894 (upper line).

2.—The after effects of the manures in 1900 (lower line).

FIGURES PER ACRE.

Plot.	Treatment for Crops of 1893 & 1894	Hay Crop.	
		1894.	1900.
		Cwt	Cwt.
1	No Manure.	17½	23
2	1 cwt Nit. of Soda.	21	25¾
3	3½ cwt. Slag.	28½	23¾
4	2½ cwt. Kainit.	17½	23¼
5	1 cwt. Nit. of Soda. 3½ cwt. Slag.	30½	21¾
6	1 cwt. Nit. of Soda. 2½ cwt. Kainit.	25¾	26
7	3½ cwt. Slag. 2½ cwt. Kainit.	35	26
8	1 cwt. Nit. of Soda. 3½ cwt. Slag. 2½ cwt. Kainit.	40½	27



their rivals. Another instructive example of the effects of manure on clover is afforded by Plot 2. Here, owing to the stimulus given to the grasses by Nitrate of Soda, clover never obtained a footing, it gave up the contest at the very beginning, and has almost been suppressed.

Summary.—

Experiments on Meadow or Old Land Hay have been conducted during the past few years in all parts of the North of England, from the east coast of Durham to the west coast of Cumberland. A systematic account of each of these experiments has appeared in several of the Annual Reports of the College; some general features of the work are here described of which the following summary may be given:—

(1) There are two well marked classes of grass land in the North of England requiring different manurial treatment.

(2) Land *not* markedly benefited by Basic Slag should usually receive small and frequent dressings of complex manures.

(3) Land that *is* markedly benefited by Slag should receive large (7-10 cwt.) and occasional dressings of this manure either by itself, or with a potash manure.

(4) If Slag is to prove markedly beneficial the conditions must be such as to favour the growth of clover, for Slag improves land largely through the agency of clover.

(5) White clover spreads quickly over poor soil on which the grasses are thin, but is quickly displaced when the latter became strong. (See diagram, p. 81.)

(6) On poor pastures otherwise suitable, Slag may fail to benefit because of a lack of Potash (see diagram, p. 75).

(7) When grass land is suitably manured fertility tends to accumulate. A number of the experiments show this. Instances are given in the diagrams on pp. 75 and 77.

(8) The value of the residue of an artificial manure applied to grass land depends much more on the character of the soil than upon the character of the manure. (See table, p. 78.)

(9) Provided the mixture is a well-balanced and suitable one, that manure which, over a series of years, gives the highest immediate returns, is most likely to leave the greatest residue. That is to say, in the manuring of grass land, the object should be to feed the plant, *not* to lay up stores in the soil. (Compare the effects produced by "soluble" and "insoluble" manures in the table on p. 78.)

THE INFLUENCE OF MANURES ON THE BOTANICAL COMPOSITION OF THE HERBAGE OF THE CUMBERLAND OLD LAND HAY STATIONS.*

By PROFESSOR SOMERVILLE.

In carrying out experiments on the improvement of permanent grass land one cannot but feel that it is, on the whole, unsatisfactory to rest content with the mere weighing of the produce. In passing the crop of a series of plots over the weigh-bridge one is often conscious, from various indications, that the quality or feeding property of the different *lots* is very varied, and one wants to lay hold of some scale that may be utilised as a test of quality. Variation in quality of the mixed herbage of a meadow may be indicated by many signs. Weight, aroma, and colour all tell something; and such laboratory tests as chemical analysis and digestive determinations are not without their value. Given a sufficient number of animals and other satisfactory conditions, the quality of herbage can be best determined by a series of feeding experiments. These, however, are much too tedious and expensive for general adoption. Finally, there is the method of botanical analysis, which consists in separating carefully selected samples of the herbage into the constituent plants that collectively form the mass.

Few forms of investigation of a simple type are more interesting than the study of the increase or disappearance of plant-species in grass land under the influence of definite manures. It is a line of research that the investigators at Rothamsted have rendered classic, and one follows their account of "The Battle of the Meadow" with all the interest that a life-and-death struggle can evoke.

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*Reprinted from *The Journal of the Board of Agriculture*, Vol. VII., No. 2, by permission of the Controller of H.M. Stationery Office.

While a knowledge of the botanical composition of herbage is most interesting, its practical importance may easily be exaggerated. Thus, for instance, while a large increase in the percentage of cocksfoot may accompany pasture improvement in one district, it does not by any means follow that corresponding improvement in another district will be associated with an increase in the relative abundance of this plant. Or, to take the case of another plant—Yorkshire fog—it may safely be asserted that whereas this species is generally indicative of unsatisfactory conditions, there are circumstances where its presence is a sign of improved fertility. In the case of some plants, however—notably white clover—an increase in their relative abundance is a reliable general index of improvement in the quality of the herbage.

The subject, in fact, is one that admits of being looked at from many different points of view. Thus, a plant that is very abundant in a light crop of hay may be very deficient when the yield is large. Then, again, a mere statement of the percentage abundance of a plant leaves much that is important out of account. Suppose, for instance, that one has three plots, one unmanured, one treated with Basic Slag, and the third treated with Kainit, and that a botanical analysis gives the following figures:—

	Treatment.	Cwt. of Hay.	Per cent. of Clover.	Cwt. of Clover.
Plot 1 -	No Manure	20	20	4
Plot 2 -	Basic Slag	25	20	5
Plot 3 -	Kainit	25	16	4

The percentage of clover is the same in the case of Plots 1 and 2, but this is no indication of the effectiveness of this manure to influence clover, for when the yield is taken into account it is seen that Plot 2 has produced 5 cwt. of this plant as against 4 cwt. on Plot 1. With the same relative abundance we have thus an increase of 25 per cent. in the absolute quantity. And, similarly, it would be erroneous to conclude that, because there is only 16 per cent. of clover in the yield of Plot 3, the Kainit has had a repressing influence on this plant. When the weight of hay is taken into account it is seen that there is as great a weight of clover produced on Plot 3 as on Plot 1, in other words, the increase in the aggregate yield induced by the use of Kainit has taken the form of an increase in the abundance of plants other than clover.

In connection with the educational work of the Department of Agriculture of the Durham College of Science, eight stations, each comprising 16 Plots of $\frac{1}{20}$-acre, were laid down on old grass land in the county of Cumberland in the winter of 1894-95. In the case of four of these stations (called Set 1) certain manures have been annually applied to the five crops of 1895 to 1899. In the first year the standard in the case of Superphosphate and Kainit was fixed at 3½ cwt. of each per acre, but in the second and subsequent years only 2½ cwt. of each of these manures was used. With the exception of this slight modification no change has been made in the system of manuring.

In the case of the four stations constituting Set 2, the manurial dressings were applied in 1895, 1897, and 1898, while nothing was used in 1896 and 1899.

The value of a botanical analysis depends entirely on the method of sampling, and on the accuracy of the subsequent separation of the species. The most exhaustive examination of the various systems of sampling, and their influence on the results, was probably that undertaken by Dr. A. Voigt, and described in Vol. xxiii. of "Die Landwirtschaftliche Jahrbücher." The essential principles of his system have been observed in all the work of hay or grass sampling undertaken by the Durham College of Science. In the case of the Cumberland Plots under review the method of procedure was as follows:—in July, 1899—when the crop of the various stations was ripe—Mr. W. T. Lawrence, the Superintendent of the Farm School at Newton Rigg, and Mr. F. Wakerley, of the Agricultural Department of the College, visited each place, the work of cutting the crop commencing after their arrival. Mr. Lawrence concerned himself entirely with the weighing of the herbage, while Mr. Wakerley gave his undivided attention to the sampling. From each swath, at intervals of five paces, a handful of grass was lifted and placed in a bag, and in this way about a stone of herbage was collected from each plot. A piece of ground was then raked clean, and on it the herbage so collected was evenly spread out, care being taken to separate any tangled or matted portions. It was then raked together and re-spread three times, when small handfuls were taken from six points of the area. This final sample, weighing about two pounds, was placed in a paper bag previously labelled, and when the sixteen samples from any station were thus collected they were at once despatched to the College, where they arrived on the following morning. There they were spread out in a greenhouse to dry, and in a few days they were fit to return to their respective bags, to be put aside till the analysis could be undertaken.

Preparation for the actual separation of the species was made by mounting on sheets specimens of all the plants likely to be met with. These specimens served for purposes of reference in cases of difficulty, and were quite indispensable. Most of the work of separation was done, under supervision, by two fourth-year students, Mr. L. Abram, B.Sc., and Mr. T. Hacking, Gold Medallist of the R.A.S.E. The mere separation of the plants of a half-pound sample of dried herbage—apart from weighings and calculations—was found to occupy the time of a worker for about six hours, the 128 samples taking practically two months to deal with.

The soil at the eight stations may be thus described:—

SET 1.	SET 2.
Blencow, clay loam.	Brampton, deep sandy loam.
Castle Carrock, gravelly loam.	Gosforth, gravelly loam.
Eskdale, moderate loam.	Kirkbampton, deep moist loam.
Glasson, deep peat.	Wigton, clay loam.

The number of plants met with in the course of the analysis was about fifty, though only about half a dozen were of sufficient abundance to be of first-rate importance. It will probably be most convenient to deal with these important plants *seriatim*; the influence of Nitrate of Soda, Sulphate of Ammonia, Superphosphate, Basic Slag, Kainit, and Lime being duly noted. At the stations of Set 1, twelve plots are concerned with these substances, while in the case of Set 2, ten plots are similarily occupied, the points dealt with by the remainder of the plots at each station being for the present left out of account, except as regards Plot 16 of Set 2, which received Lime.

In order that there may be no misapprehension it may be specifically stated that in the following pages the yield of hay, and relative and absolute abundance of the various plants, refer to the crop of 1899 only. That was the fifth year of the experiments, and by that time the manures may be supposed to have had time to produce most of the effects of which they are capable. The weights of hay and manure always refer to an acre.

Agrostis (Tables I. and II.*)—

This genus of grass was usually the most abundant constituent of the herbage, though at Gosforth it never exceeded 1·2 per cent., while at Wigton it was always under 7·5 per cent. *Agrostis*, under its different species and varieties of bent grass, black bent, water grass, poor-land twitch, etc., is generally regarded as one of our poorest grasses; and it may safely be concluded that any treatment that reduces its abundance is, to that extent at least, advantageous.

The influence on Agrostis of Nitrate of Soda when used alone.—On the whole this manure, when used by itself, has not had any very conspicuous influence on *Agrostis*. Table I. shows that Plot 2, receiving Nitrate of Soda, has at two places produced a greater, and at two places a less, percentage of *Agrostis* than Plot 1, which was wholly untreated. The

* The references are to the Tables of this Article *not* to those in the Appendix.

weight of *Agrostis* is, however, always greater on Plot 2—notably so at Castle Carrock—but so also is the weight of general herbage, except on the peaty soil of Glasson, where the Nitrate has had but little effect.

TABLE I.—EFFECTS OF MANURES ON AGROSTIS (SET 1).

Plots.	Manures per acre.					Blencow.			Castle Carrock.			Eskdale.			Glasson.		
	Nitrate of Soda.	Sulph. of Ammon.	Super.	Slag.	Kainit.	Yield of Hay.	Yield of Agrostis.		Yield of Hay.	Yield of Agrostis.		Yield of Hay.	Yield of Agrostis.		Yield of Hay.	Yield of Agrostis.	
	lbs.	lbs.	lbs.	lbs.	lbs.	cwt	%	lbs	cwt	%	lbs.	cwt	%	lbs.	cwt	%	lbs.
1	—	—	—	—	—	23½	74·7	1,966	22	23·7	583	27	23·8	719	11	44·0	542
2	112	—	—	—	—	28½	51·7	2,288	28¾	32·0	1,030	33	21·3	787	11½	51·6	650
3	—	—	280	—	—	35¼	75·0	2,961	22	23·8	586	26½	17·7	525	22	46·3	1,140
4	—	—	—	208	—	33¾	70·0	2,646	21¾	17·9	436	21½	17·5	421	16¾	44·5	834
5	—	—	—	—	280	32¾	62·8	2,303	22	18·3	450	24¼	15·7	426	17¾	50·3	999
6	112	—	230	—	—	33¼	68·8	2,362	23	18·8	484	31¾	23·8	846	21	35·1	825
7	112	—	—	—	280	28½	63·0	2,010	25½	23·1	659	37¾	17·1	722	18¾	58·1	1,220
	—	—	280	—	280	25½	62·8	1,793	25¼	17·3	489	37	16·8	696	20	38·9	871
9	112	—	280	—	280	29¼	47·3	1,549	26½	13·2	391	38½	23·0	991	20¼	25·7	582
10	112	—	—	208	280	29	33·7	1,094	25¾	17·5	504	38	16·8	715	24¾	25·6	709
11	112	—	140	104	280	29¼	41·1	1,346	27½	18·2	560	35	22·8	893	23½	26·2	689
12	—	86	—	208	280	24¾	36·0	997	30½	21·9	718	30¼	25·4	860	19¼	27·2	586

The influence on Agrostis of Nitrate of Soda when added to Superphosphate.—To ascertain this we compare Plot 3, Table I. (Superphosphate alone), with Plot 6 (Superphosphate and Nitrate). At two of the stations (Blencow and Glasson) the addition of the Nitrate has not increased the general yield, while at Castle Carrock and Eskdale this treatment has produced an increase, though only of a single cwt. at the former station. As regards *Agrostis,* it will be seen that the percentage and actual yield have been rather markedly reduced at all the stations except Eskdale.

The influence on Agrostis of Nitrate of Soda when added to Kainit.—Comparison of Plots 5 and 7, Table I., will show that at all the stations the Nitrate, when added to Kainit, has increased the percentage of *Agrostis.*

The influence on Agrostis of Nitrate of Soda when added to both Superphosphate and Kainit (compare Plots 8 and 9, Table I.).—With the single exception of Eskdale, the addition of Nitrate of Soda to these mineral manures has very markedly reduced both the percentage and actual weight of *Agrostis.*

The influence on Agrostis of a double and triple dose of Nitrate of Soda.—This was tested on Plots 2, 7, and 8 at the stations of Set 2 (see Table II.). The plots concerned received equal quantities of minerals, but Plot 7 got ½ cwt. of Nitrate, Plot 2 received 1 cwt., and Plot 8 1½ cwt. of that manure. Gosforth may be left out of account, as at that station there was no appreciable quantity of *Agrostis* on any of the plots. At two of the other stations the largest dressing of Nitrate—where single and triple doses are compared—produced the smallest percentage and yield of *Agrostis,* and the same is true where a single dose of Nitrate is compared with a double.

TABLE II.—EFFECTS OF MANURES ON AGROSTIS (SET 2).

Plots.	Manures per Acre.				Brampton.			Kirkbampton.			Wigton.		
	Nitrate of Soda.	Super	Slag.	Kainit.	Yield of Hay.	Yield of Agrostis.		Yield of Hay.	Yield of Agrostis.		Yield of Hay.	Yield of Agrostis.	
	lbs.	lbs.	lbs.	lbs.	cwt.	°/₀	lbs.	cwts.	°/₀	lbs.	cwt.	°/₀	lbs.
1	—	—	—	—	27¼	24·2	738	29	34·5	1,120	26½	3·4	100
2	112	392	—	392	25	29·1	814	29¾	27·8	926	27	6·8	205
3	112	196	—	392	21¾	31·3	62	31¾	28·0	995	24	7·4	198
4	112	588	—	392	20¾	30·7	713	27¾	36·0	1.118	29¼	2·8	91
5	112	392	—	196	22¾	39·4	1,003	26¼	38·0	1,117	30½	2·7	92
6	112	392	—	588	25¼	36·8	1,040	30	41·2	1,384	33¼	3·2	119
7	56	392	—	392	30¼	37·0	1,253	30¾	39·3	1,353	29	5·1	165
8	168	392	—	392	29¾	32·3	1,076	34	42·4	1,614	34½	2·8	108
9	56	—	320	392	29½	29·8	984	35¼	38·5	1,519	34	1·2	45
10	56	—	480	392	29¾	34·3	1,142	33¼	37·2	1,385	38¼	5·1	218

Summary of the results on Agrostis obtained with Nitrate of Soda.—Where the Nitrate of Soda is used in a manner that general experience has shown to be bad—that is, alone, or in conjunction with Kainit only—it has, on the whole, markedly encouraged the growth of *Agrostis;* but where used in a more rational manner as an addition to Superphosphate, or to Superphosphate combined with Kainit, it has only twice in eight times failed to diminish the percentage of this undesirable grass.

The influence on Agrostis of Nitrate of Soda as compared with Sulphate of Ammonia.—Plots 10 and 12 of the stations of Set 1 (Table I.) have always received similar dressings of minerals, the only difference in the treatment consisting in the Nitrogen of Plot 10 being derived from Nitrate of Soda, whereas on Plot 12 it was supplied by Sulphate of Ammonia. Without an exception the Sulphate of Ammonia has always produced a larger percentage of *Agrostis.* This result is in conformity with that obtained at Rothamsted, and is precisely what our knowledge of soil physics would have led us to expect. Sulphate of Ammonia is retained by the surface layers of the soil to a much greater extent than is the case with Nitrate of Soda, and, as a consequence, the former manure is especially adapted to stimulate and encourage the growth of a shallow-rooted plant like *Agrostis.*

The influence on Agrostis of Superphosphate when used alone (compare Plots 1 and 3, Table I.).—At three of the four stations *Agrostis* has been increased. At Glasson, where this manure doubled the crop of hay, it more than doubled the weight of *Agrostis.*

The influence on Agrostis of Superphosphate when added to Nitrate of Soda (compare Plots 2 and 6, Table I.).—Here the percentage of *Agrostis* has been reduced at three of the four stations, but, in spite of this, the actual weight of *Agrostis* produced has, on three occasions, been greater where Superphosphate was applied.

The influence on Agrostis of Superphosphate when added to Kainit (compare Plots 5 and 8, Table I.).—The tendency has here been in the direction of reduction of *Agrostis.* Only on one occasion has Superphosphate produced an increase.

The influence on Agrostis of Superphosphate when added to both Nitrate of Soda and Kainit (compare Plots 7 and 9, Table I.).—With the exception of Eskdale, the Superphosphate, when used as above, has effected a marked reduction in the amount of *Agrostis.*

The influence on Agrostis of a double and triple dose of Superphosphate (compare Plots 2, 3, and 4, Table II.).—At each of the three stations, where *Agrostis* was fairly abundant, the double dressing of Superphosphate invariably diminished the percentage yield of this grass, while the triple dressing had a similar effect in two cases out of three.

Summary of the results on Agrostis obtained with Superphosphate.—Ten times in sixteen the Superphosphate has either diminished, or at least failed to increase, the percentage of *Agrostis*, and the tendency, where increasing quantities of this manure have been used, has been strongly in the direction of suppressing the growth of this plant.

The influence on Agrostis of Superphosphate in comparison with Basic Slag.—This was tested twice at each of the stations of Set 1, and once at each of the stations of Set 2. In every case the comparison was between equal amounts of Phosphoric Acid.

When the comparison was between the two forms of Phosphate, unaccompanied by any other manure (Plots 3 and 4, Table I.), the Superphosphate invariably produced the larger amount of *Agrostis.* When the comparison was between the two forms of Phosphate in the presence of Nitrate of Soda and Kainit (Plots 9 and 10, Table I.; and 7 and 9, Table II.) a similar result was obtained at three of the four stations of Set 1, and at all the stations at Set 2. As the result, therefore, of eleven tests, Superphosphate was found to surpass Basic Slag in its stimulating influence on *Agrostis* no less than ten times. As in the great majority of cases the aggregate yield by Superphosphate was larger than that produced by Slag, *Agrostis* is even more encouraged by the former than the percentage figures would indicate.

In further proof of this influence of Superphosphate we may compare Plots 10 and 11, Table I. The former plot received all its Phosphate as Slag, while the latter received half from Slag and half from Superphosphate. The introduction of Superphosphate has, without an exception, increased the percentage of *Agrostis*.

The influence on Agrostis of Kainit when used alone (Plots 1 and 5, Table I.).—At three of the four stations Kainit reduced the percentage of *Agrostis*, the exception being found on the peaty soil of Glasson.

The influence on Agrostis of Kainit when added to Nitrate of Soda (Plots 2 and 7, Table I.). A precisely similar result was got in this case, the only exception being again at Glasson.

The influence on Agrostis of Kainit when added to Superphosphate (Plots 3 and 8, Table I.).—In this case there is no exception to the repressing action of Kainit on *Agrostis*.

The influence on Agrostis of Kainit when added to both Nitrate of Soda and Superphosphate (Plots 6 and 9, Table I.).—Here also Kainit has never failed to reduce the percentage of *Agrostis*.

The influence on Agrostis of a double and triple dose of Kainit.—(Plots 2, 5, and 6, Table II.). On the whole there is but little difference in the percentage of *Agrostis* produced by varying amounts of Kainit.

Summary of the Results on Agrostis obtained with Kainit.—Of the sixteen separate tests carried out on the four stations of Set 1, fourteen showed that Kainit has a repressing influence on the growth of *Agrostis*. The two exceptions were met with on the peat of Glasson, the one occurring where Kainit was used alone, and the other where it was added to Nitrate of Soda—both irrational methods of application. Used, as it should be, along with Phosphate—either with or without Nitrogen—there is no exception to the tendency of Kainit to reduce the percentage of *Agrostis*.

The influence on Agrostis of Lime.—At each of the stations of Set 2 two plots (Nos. 15 and 16)* received precisely similar amounts of a mixture of Artificials, the only difference in the treatment of these plots consisting in the application of 5 cwt. per acre of Pulverised Lime to Plot 16 for each of the crops of 1895, 1897, 1898. The influence of the Lime was very slight, so far as the aggregate yield of hay is concerned, but its effect on *Agrostis* was striking and conclusive, for in no case did it fail to reduce both the percentage and weight of this plant.

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* To save space details are not shown here.

Cocksfoot (Tables III. and IV.).—

TABLE III.—EFFECTS OF MANURES ON COCKSFOOT (SET 1).

Plots.	Manures per acre.					Blencow.			Castle Carrock.			Eskdale.		
	Nitrate of Soda.	Sulph. of Ammon.	Super.	Slag.	Kainit.	Yield of Hay.	Yield of Cocksfoot.		Yield of Hay.	Yield of Cocksfoot.		Yield of Hay.	Yield of Cocksfoot.	
	lbs.	lbs.	lbs.	lbs.	lbs.	cwt.	°/₀	lbs.	cwt.	°/₀	lbs.	cwt.	°/₀	lbs.
1	—	—	—	—	—	23½	3·9	102	22	15·6	384	27	12·2	368
2	112	—	—	—	—	28½	2·4	76	28¾	6·6	212	33	13·4	495
3	—	—	280	—	—	35¼	0·9	35	22	5·2	128	26½	11·2	332
4	—	—	—	208	—	33¾	5·2	196	21¾	7·5	182	21½	8·2	197
5	—	—	—	—	280	32¾	3·7	135	22	10·3	253	24¼	15·5	420
6	112	—	280	—	—	33½	7·2	268	23	5·1	131	31¾	9·2	327
7	112	—	—	—	280	28½	1·1	35	25½	6·7	191	37¾	14·7	621
8	—	—	280	—	280	25½	1·5	42	25¼	4·2	118	37	13·2	547
9	112	—	280	—	280	29¼	6·0	196	26½	7·0	207	38½	6·2	267
10	112	—	—	208	280	29	14·2	461	25¾	8·6	248	38	8·6	365
11	112	—	140	104	280	29¼	11·7	383	27½	3·6	110	35	11·7	458
12	—	86	—	208	280	24¾	11·8	327	30½	7·8	266	30¼	10·9	369

This grass was fairly abundant at five of the eight stations, the exceptions being Glasson, Brampton, and Kirkbampton, where it was either very scarce or altogether absent. Table III., which deals with the behaviour of cocksfoot at the stations constituting Set 1, therefore, contains details of three places, while Table IV. shows the figures for two stations only—namely, Gosforth and Wigton.

The influence on Cocksfoot of Nitrate of Soda.—While the relationship of cocksfoot and subsequent plants to this and other manures might be examined in as much detail as in the case of *Agrostis,* it will probably be sufficient if the results are stated somewhat more generally.

Neither alone nor in combination has Nitrate of Soda had any very conspicuous influence on this plant.

At the two stations of Set 2, referred to in Table IV., Nitrate of Soda, where used in varying quantities, has to a slight extent increased the percentage of cocksfoot (compare Plots 2, 7, 8).

The influence on Cocksfoot of Nitrate of Soda as compared with Sulphate of Ammonia (Plots 10 and 12, Table III.).—The results obtained here show that Nitrate of Soda has produced the larger percentage of cocksfoot twice out of three times. This is in conformity with general experience, the result being due to the fact that Nitrate of Soda sinks more quickly and deeply into the soil than Sulphate of Ammonia, and is thus brought more thoroughly into contact with the roots of deep-rooted plants, such as cocksfoot.

The influence on Cocksfoot of Superphosphate.—When used alone, or when added to Kainit, Superphosphate never failed to diminish the percentage of cocksfoot. Under other circumstances the action of this manure is not so pronounced, but, on the aggregate of twelve tests at the three stations of Set 1, Superphosphate has reduced the percentage of cocksfoot nine times.

Varying amounts of Superphosphate (Plots 2, 3, 4, Table IV.) have not had much effect on the relative abundance of cocksfoot.

The influence on Cocksfoot of Superphosphate in Comparison with Basic Slag.—At the five stations concerned a given amount of Phosphoric Acid had seven times out of eight produced a greater percentage and weight of cocksfoot when in the form of Slag than when applied as Superphosphate. At the two stations where varying amounts of Slag were tried, the percentage of cocksfoot was lower with a large than with a small amount of Slag.

TABLE IV.—EFFECTS OF MANURES ON COCKSFOOT (SET 2).

Plots.	Manures per acre.				Gosforth.			Wigton.		
	Nitrate of Soda.	Super.	Slag.	Kainit.	Yield of Hay.	Yield of Cocksfoot.		Yield of Hay.	Yield of Cocksfoot.	
	lbs.	lbs.	lbs.	lbs.	cwt.	°/o	lbs.	cwt.	°/o	lbs.
1	—	—	—	—	27½	14·7	452	26½	4·8	142
2	112	392	—	392	25	17·0	476	27	6·6	199
3	112	196	—	392	21	16·5	388	24	14·0	376
4	112	588	—	392	23¾	17.6	468	29¼	9·3	304
5	112	392	—	196	23	8·5	218	30½	14·5	495
6	112	392	—	588	23¼	15·4	401	33¼	13·1	487
7	56	392	—	392	23½	17·6	463	29	6·6	214
8	168	392	—	392	24¾	22·6	626	34½	7·2	278
9	56	—	320	392	23¼	18·8	489	34	16·1	613
10	56	—	480	392	21¾	12·2	297	34¼	12·2	522

The influence on Cocksfoot of Kainit and Lime.—Apparently neither of these two manures has had any particular effect on this plant.

Crested Dogstail (Tables V. and VI.).—

This plant was generally present in moderate quantity at the four stations of Set 1, and at three of the stations of Set 2.

The influence on Crested Dogstail of Nitrate of Soda.—The action of this manure on crested dogstail is very peculiar and yet perfectly consistent. In every case where Nitrate of Soda is used alone, or as an addition to Kainit, it has reduced the percentage of this grass; while, equally invariably it has increased the percentage of crested dogstail when used (*a*) with Superphosphate or (*b*) with both Superphosphate and Kainit. This result is the converse of the action of Nitrate of Soda on *Agrostis* (see page 9), and doubtless admits of explanation. For the present, however, it need only be said that the two cases furnish instances of a poor plant (*Agrostis*) being repressed and a good plant (crested dogstail) being encouraged by the judicious use of Nitrate of Soda, whereas the opposite is the case when the same manure is applied in an irrational manner.

TABLE V.—EFFECTS OF MANURES ON CRESTED DOGSTAIL (SET 1).

Plots.	Manures per acre.					Blencow.			Castle Carrock.			Eskdale.			Glasson.		
	Nitrate of Soda.	Sulph. of Amm.	Super.	Slag.	Kainit.	Yield of Hay.	Yield of Dogstail.		Yield of Hay.	Yield of Dogstail.		Yield of Hay.	Yield of Dogstail.		Yield of Hay.	Yield of Dogstail.	
	lbs.	lbs.	lbs.	lbs.	lbs.	cwt.	%	lbs.	cwt.	%	lbs.	cwt.	%	lbs.	cwt.		lbs.
1	—	—	—	—	—	23½	4·1	107	22	5·8	142	27	4·4	133	11	0·2	2
2	112	—	—	—	—	28½	2·4	76	28¾	4·1	132	33	2·7	99	11½	0·1	1
3	—	—	280	—	—	35¼	3·2	126	22	7·4	182	26½	5·8	172	22	0·2	4
4	—	—	—	208	—	33¾	3·5	132	21¾	10·9	265	21½	4·1	98	16¾	0·3	5
5	—	—	—	—	280	32¾	3·1	113	22	7·5	184	24¼	2·8	76	17¾	—	—
6	112	—	280	—	—	33¼	1·8	67	23	7·2	185	31¾	5·1	181	21	—	—
7	112	—	—	—	280	28½	4·7	150	25½	7·7	219	37¾	6·3	266	18¾	1·3	27
8	—	—	280	—	280	25½	7·4	211	25¼	3·7	104	37	3·8	157	20	2·6	58
9	112	—	280	—	280	29¼	10·1	330	26½	3·9	115	33½	4·0	172	20¼	3·1	70
10	112	—	—	208	280	29	7·2	233	25¾	6·2	178	38	3·1	131	21¾	1·0	27
1	112	—	140	104	280	29¼	5·5	180	27½	7·9	243	35	5·5	215	23½	4·2	110
12	—	86	—	208	280	27¾	11·2	310	30½	7·4	252	30¼	2·5	84	19¼	1·9	40

The influence on Crested Dogstail of Nitrate of Soda, as compared with Sulphate of Ammonia (Plots 10 and 12, Table V.).—With only one exception (Eskdale) the latter manure has produced a larger percentage of crested dogstail, a result that is doubtless associated with the shallow-rooted character of the plant.

The influence on Crested Dogstail of Superphosphate, Kainit, and Lime.—On the whole, the tendency of each of these manures has been in the direction of increasing crested dogstail, though it cannot be said that the influence has been very marked. Varying quantities of Superphosphate and Kainit made but little difference to the percentage of this plant, and the same is true with regard to Basic Slag, which, in respect to its general influence, did not differ much from Superphosphate.

TABLE VI.—EFFECTS OF MANURES ON CRESTED DOGSTAIL (SET 2).

Plots.	Manures per Acre.				Brampton.			Gosforth.			Kirkbampton.		
	Nitrate of Soda.	Super.	Slag.	Kainit.	Yield of Hay.	Yield of Dogstail.		Yield of Hay.	Yield of Dogstail.		Yield of Hay.	Yield of Dogstail.	
	lbs.	lbs.	lbs.	lbs.	cwt.	°/。	lbs.	cwt.	°/。	lbs.	cwt.	°/。	lbs.
1	—	—	—	—	27¼	6·4	195	27½	12·8	394	29	2·9	94
2	112	392	—	392	25	1·3	36	25	8·6	240	29¾	2·9	96
3	112	196	—	392	21¾	2·4	58	21	19·1	449	31¾	5·0	177
4	112	588	—	392	20¾	1·2	27	23¾	11·4	303	27¾	4·0	124
5	112	392	—	196	22¾	2·1	53	23	14·0	360	26¼	2·3	67
6	112	392	—	588	25¼	1·9	53	23¼	14·0	364	30	7·0	235
7	56	392	—	392	30¼	1·3	44	23½	15·6	410	30¾	3·8	130
8	168	392	—	392	29¾	6·0	199	24¾	11·1	307	34	2·2	83
9	56	—	320	392	29½	5·3	175	23¼	10·2	265	35¼	3·0	118
10	56	—	480	392	29¾	3·0	99	21¾	23·8	579	33¼	3·7	137

Yorkshire Fog (Tables VII. and VIII.).—

This is a grass which is generally considered of inferior quality, though, at the same time, it is often abundant in high-class meadows and pastures. It often accompanies improvement of grass land, though it is probably an indication rather than the cause of such improvement. It was present in considerable quantity on all the stations under review.

The influence on Yorkshire Fog of Nitrate of Soda.—Those who have observed how well Yorkshire fog flourishes on old manure heaps, and other situations where nitrogen is abundant, will not be surprised to learn that Nitrate of Soda, with two unimportant exceptions, has increased the percentage and yield of this plant. In many cases its yield has been more than doubled by 1 cwt. per acre per annum of this manure. Although this is the case, it has not been found that an increase in the amount of Nitrate of Soda, from ½ cwt. to 1 and 1½ cwt. per acre, has been accompanied by any increase in the percentage of Yorkshire fog. No doubt this is due to the fact that, being a plant of only moderate size, its development is much interfered with by the accompanying herbage which large dressings of Nitrate of Soda force to luxuriant growth.

No constant difference could be traced in the relative effect on Yorkshire fog of Nitrate of Soda and Sulphate of Ammonia.

TABLE VII.—EFFECTS OF MANURES ON YORKSHIRE FOG (SET 1).

Plots.	Manures per acre.					Blencow.			Castle Carrock.			Eskdale.			Glasson.		
	Nitrate of Soda.	Sulph. of Ammon.	Super.	Slag.	Kainit.	Yield of Hay.	Yield of Y. Fog.		Yield of Hay.	Yield of Y. Fog.		Yield of Hay.	Yield of Y. Fog.		Yield of Hay.	Yield of Y. Fog.	
	lbs.	lbs.	lbs.	lbs	lbs.	cwt	%	lbs.	cwt	%	lbs.	cwt	%	lbs.	cwt	%	lbs.
1	—	—	—	—	—	23½	6·0	157	22	13·8	340	27	6·9	208	11	1·9	23
2	112	—	—	—	—	28½	8·2	261	28¾	18·2	586	33	7·7	284	11¼	3·8	47
3	—	—	280	—	—	35¼	6·9	272	22	12·7	312	26½	8·7	250	22	4·9	120
4	—	—	—	208	—	33¾	3·1	117	21¾	15·7	382	21½	7·2	173	16¾	7·4	138
5	—	—	—	—	280	32¾	7·2	264	22	12·7	312	24¼	4·3	116	17¾	5·1	101
6	112	—	280	—	–	33¼	8·5	316	23	12·9	332	31¾	1·45	515	21	11·9	279
7	112	—	—	—	280	28½	10·2	325	25½	12·1	315	37¾	12·8	541	18¾	3·3	69
8	—	—	280	—	280	25½	10·8	308	25¼	5·8	164	37	9·8	406	20	9·6	215
9	112	—	280	—	280	29¼	11·5	376	26¼	13·0	385	38½	24·0	1034	20¼	11·7	265
10	112	—	—	208	280	29	18·4	597	25¾	13·5	389	38	14·2	604	24¾	6·7	185
11	112	—	140	104	280	29¼	19·1	625	27½	13·7	421	35	9·1	356	23½	6·6	173
12	—	86	—	208	280	24¾	25·4	704	30½	12·9	440	30¼	11·9	403	19¼	12·7	273

The influence on Yorkshire Fog of Superphosphate.—In the four tests conducted at each of three stations—Blencow, Eskdale, Glasson—there is no exception to the result that the percentage of Yorkshire fog is increased by the use of Superphosphate, whether alone or in combination with other manures. At Castle Carrock, on the other hand, the opposite is the case three times in four. Evidently, therefore, local conditions have much to do with determining the effects of the influence of Superphosphate on Yorkshire fog, and in any case, it is more than likely that phosphatic manure encourages this species only indirectly, through the Nitrogen which is stored up in the soil by the leguminous vegetation that usually follows the application of such a manure.

TABLE VIII.—EFFECTS OF MANURES ON YORKSHIRE FOG (SET 2).

Plots.	Manures per Acre.				Brampton.			Gosforth.			Kirkbampton.			Wigton.		
	Nitrate of Soda.	Super.	Slag.	Kainit.	Yield of Hay.	Yield of Y. Fog.		Yield of Hay.	Yield of Y. Fog.		Yield of Hay.	Yield of Y. Fog.		Yield of Hay.	Yield of Y. Fog.	
	lbs.	lbs.	lbs.	lbs.	cwt.	°/o	lbs.	cwt.	°/o	lbs.	cwt.	°/o	lbs.	cwt.	°/o	lbs.
1	—	—	—	—	27¼	14·5	442	27½	9·0	277	29	13·4	435	26½	11·3	335
2	112	392	—	392	25	13·4	375	25	13·3	372	29¾	18·4	613	27	18·4	556
3	112	196	—	392	21¾	11·5	280	21	16·3	383	31¾	13·2	469	24	9·7	260
4	112	588	—	392	20¾	17·5	406	23¾	10·6	281	27¾	7·6	236	29¼	23·6	773
5	112	392	—	196	22¾	16·7	425	23	13·1	337	26¼	8·7	255	30½	8·1	276
6	112	392	—	588	25¼	19 3	545	23¼	12·1	315	30	13·3	446	33¼	14·5	539
7	56	392	—	392	30¼	18·0	609	23½	10·4	273	30¾	21·0	723	29	24·5	795
8	168	392	—	392	29¾	14·8	493	24¾	11·6	321	34	16·0	609	34½	20·6	795
9	56	—	320	392	29½	12·7	419	23¼	17·9	466	35¼	10·4	410	34	21·7	826
10	56	—	480	392	29¾	15·4	513	21¾	10·4	253	33¼	8·1	301	38¼	21·9	938

At two of the four stations of Set 2 an increase in the percentage of Yorkshire fog kept pace with an increase in the dressing of Superphosphate. At the other two stations this result is not observable.

There is no consistent difference in the influence of Superphosphate and Slag on this plant.

The influence on Yorkshire Fog of Kainit.—At Blencow Kainit has always increased the percentage of Yorkshire fog, while at Castle Carrock the reverse has almost as invariably happened. At the other two stations of Set 1 no consistent influence in this respect can be traced, though the tendency is towards an increase. The same is true where varying amounts of Kainit were used at the four stations of Set 2, in three cases a considerably larger amount of Yorkshire fog being produced by the largest than by the smallest dose of Kainit.

The influence on Yorkshire Fog of Lime.—Three times in four Lime reduced the percentage of this plant.

Leguminosæ (Tables IX. and X.).—

The members of this family of plants that were chiefly met with were white and red clover, bird's foot trefoil, meadow vetchling, *Vicia sepium*, and *V. cracca*. All were separately determined, but here they may be regarded collectively.

The influence on Leguminosæ of Nitrate of Soda.—Eleven times in sixteen tests (Set 1) these plants were reduced in amount by the use of Nitrate, the diminution in quantity being often very large. Where this manure was increased from a half to one and a half cwt. per acre (Plots 7 and 8, Table X.) the *Leguminosæ* were invariably reduced, sometimes almost to the point of total disappearance. With but one exception a larger percentage of *Leguminosæ* was got under the influence of Nitrate of Soda than where Sulphate of Ammonia was used (Plots 10 and 12, Table IX.). This result was also obtained at Rothamsted, and has been observed elsewhere.

The influence on Leguminosæ of Superphosphate.—At Blencow and Glasson this family of plants has been increased at each station three times in four tests, but at the other two stations the tendency has been rather in the opposite direction. This illustrates the well-known fact that phosphatic manures sometimes fail absolutely to encourage the increased growth of clovers and similar plants. Where, in the second set of stations, Superphosphate is increased from 196 lbs. (Plot 3) to 392 lbs. (Plot 2) and finally to 588 lbs. (Plot 4) there is in no case any perceptible increase in the *Leguminosæ*; in fact, with but one exception (Kirkbampton), a higher percentage of these plants is got with the smallest than with the largest dose of Superphosphate.

TABLE IX.—EFFECTS OF MANURES ON LEGUMINOSÆ (SET 1).

Plots.	Manures per Acre.					Blencow.			Castle Carrock.			Eskdale.			Glasson.		
	Nitrate of Soda.	Sul. of Am.	Super.	Slag.	Kainit.	Yield of Hay.	Yield of Leguminosæ.		Yield of Hay.	Yield of Leguminosæ.		Yield of Hay.	Yield of Leguminosæ.		Yield of Hay.	Yield of Leguminosæ.	
	lbs.	lbs.	lbs.	lbs.	lbs.	cwt	°/₀	lbs.	cwt	°/₀	lbs.	cwt	°/₀	lbs.	cwt	°/₀	lbs.
1	—	—	—	—	—	23½	2·3	60	22	5·1	125	27	7·6	229	11	8·5	104
2	112	—	—	—	—	28½	1·5	47	28¾	2·0	64	33	5·5	203	11½	4·2	52
3	—	—	280	-	—	35¼	5·2	205	22	1·4	34	26½	9·6	284	22	24·6	(06
4	—	—	—	208	—	33¾	5·2	196	21¾	2·3	56	21½	4·6	110	16¾	19·4	363
5	—	—	—	—	280	32¾	3·1	113	22	5·2	128	24½	20·4	554	17¾	21·6	429
6	112	—	280	—	—	33¼	—	—	23	1·8	46	31¾	1·9	67	21	17·4	409
7	112	—	—	—	280	28½	8·2	261	25½	5·3	151	37¾	13·6	575	18¾	18·5	388
8	—	—	280	—	280	25½	8·3	237	25¼	18·4	520	37	16·2	671	20	17·1	383
9	112	—	280	—	280	29¼	8·4	275	26½	14·3	424	38½	9·9	426	20¼	25·5	578
10	112	—	—	203	280	29	8·4	272	25¾	17·8	513	38	13·9	591	21¾	33·8	936
11	112	—	140	104	280	29¼	3·1	101	27½	13·4	412	35	8·5	333	23½	27·9	734
12	—	86	—	208	280	24¾	1·5	41	30½	9·2	314	30¼	17·2	582	19¼	26·2	564

So far as the relative effects of Superphosphate and Slag on *Leguminosæ* are concerned, little if any difference is observable. Slag always equalled or excelled Superphosphate where applied along with Nitrate of Soda and Kainit to the stations of Set 1, but this result is not borne out in the second set of stations. Probably the popular idea that it is largely a question of soil is the right one.

The influence on Leguminosæ of Kainit.—One of the most conspicuous results of the Rothamsted investigations is the demonstration of the dependence of the *Leguminosæ* on a plentiful supply of available Potash. This result has been amply confirmed in the experiments under discussion. With a single exception—that is to say, fifteen times in sixteen—the *Leguminosæ* are much more abundant where Kainit is applied than where it is withheld. The one exception, too, can be easily explained, being due to the fact that at Glasson Plot 3 contained an altogether abnormal amount of *V. cracca*, so that the Kainit plot with which it compares—No. 8—shows a slight falling off in total *Leguminosæ*. Averaging the four plots that got no Kainit at each of the four stations of Set 1—that is 16 plots in all—with the 16 corresponding plots that received annually 2½ cwt. of Kainit per acre in 1896-1899, and 3½ cwt. of Kainit in 1895, we have the following results:—

	Average Yield of Hay, 1899.	Average percentage of Leguminosæ, 1899.	Average weight per acre of Leguminosæ, 1899.
	cwt.		lbs.
Average of Plots 1, 2, 3, 6, without Kainit.	25	6·2	174
Average of Plots 5, 7, 8, 9, with Kainit.	26¾	13·4	401

It will be seen that although the Kainit has added only 1¾ cwt. of hay to the general yield, it has more than doubled the percentage and yield of *Leguminosæ*, and has doubtless greatly improved the quality of the produce.

TABLE X.—EFFECTS OF MANURES ON LEGUMINOSÆ (SET 2).

Plots.	Manures per Acre.				Brampton.			Gosforth.			Kirkbampton.			Wigton.		
	Nitrate of Soda.	Super.	Slag.	Kainit.	Yield Hay.	Yield of Leguminosæ.		Yield of Hay.	Yield of Leguminosæ.		Yield of Hay.	Yield of Leguminosæ.		Yield of Hay.	Yield of Leguminosæ.	
	lbs.	lbs.	lbs.	lbs.	cwt.	°/₀	lbs.	cwt.	°/₀	lbs.	cwt.	°/₀	lbs.	cwt.	°/₀	lbs.
1	—	—	—	—	27¼	9·9	302	27½	2·4	73	29	0·6	19	26½	1·3	38
2	112	392	—	392	25	6·0	168	25	5·2	145	29¾	1·6	53	27	3·9	117
3	112	196	—	392	21¾	8·4	204	21	3·0	70	31¾	2·5	88	24	2·8	75
4	112	588	—	392	20¾	7·7	178	23¾	4·5	119	27¾	0·6	18	29¼	0·4	13
5	112	392	—	196	22¾	9·0	229	23	3·0	77	26¼	1·4	41	30½	0·3	27
6	112	392	—	588	25¼	9·3	263	23¼	4·0	104	30	3·4	114	33¼	2·2	81
7	56	392	—	392	30¼	3·5	118	23½	2·4	63	30¾	4·5	154	29	3·4	110
8	168	392	—	392	29¾	2·8	93	24¾	1·6	44	34	0·9	34	34½	0·2	7
9	56	—	320	392	29½	6·4	211	23¼	1·9	49	35¼	1·0	39	34	0·3	11
10	56	—	480	392	29¾	6·8	226	21¾	1·5	36	33¼	1·4	52	38¼	1·9	81

On examining the effects on the *Leguminosæ* of increasing doses of Kainit (Table X.) it will be seen that the largest dose has at each station produced the highest percentage of these plants, the average for the four stations being—

196 lbs. Kainit gave 3·7 per cent. Leguminosæ = 93 lbs. per acre.
392 ,, ,, ,, 4·2 ,, ,, = 121 ,, ,,
538 ,, ,, ,, 4·7 ,, ,, = 140 ,, ,,

The increase in the percentage and weight of *Leguminosæ* is perhaps less than might have been expected, which would indicate that a dose of about 2 cwt. of Kainit is as much as is usually necessary for annual application to old-land hay.

The influence on Leguminosæ of Lime.—The experiments have furnished no evidence to justify any definite conclusion in regard to this matter.

Ribwort (Tables XI. and XII.).—

As each of the eight stations showed a considerable, generally a large, amount of ribwort (*Plantago lanceolata*), it would appear desirable to examine the behaviour of manures towards this plant, which belongs to neither of the families we have already looked at—the *Gramineæ* and *Leguminosæ.* Ribwort is characterised by the possession of a well developed tap-root, so that we should expect that it would be fairly independent of supplies of superficial nourishment.

The influence on Ribwort of Nitrate of Soda.—Twelve times in sixteen at the stations of Set 1 the percentage of this plant has been reduced by Nitrate of Soda, and in many cases the reduction is very striking. This result is probably largely due to the fact that when the general herbage is forced by Nitrate of Soda, ribwort, being rather a small plant, is partly crowded out.

Ribwort holds its own fairly well under the influence of increasing doses of Nitrate; it is only when a triple dressing is used (Plot 8, Table XII.) that the percentage of this plant shows a tendency to decline. In respect of this, however, it may be noted that ribwort has a much greater tendency to disappear before the influence of increasing doses of Nitrate at Glasson than at any of the other stations.

Sulphate of Ammonia has not had such a repressing influence on this plant as Nitrate of Soda.

TABLE XI.—EFFECTS OF MANURES ON RIBWORT (SET I).

Plots.	Manures per acre.					Blencow.			Castle Carrock.			Eskdale.			Glasson.		
	Nitrate of Soda.	Sulph. of Ammon.	Super.	Slag.	Kainit.	Yield of Hay.	Yield of Ribwort.		Yield of Hay.	Yield of Ribwort.		Yield of Hay.	Yield of Ribwort.		Yield of Hay.	Yield of Ribwort.	
	lbs.	lbs.	lbs.	lbs.	lbs.	cwt	°/₀	lbs.	cwt	°/₀	lbs.	cwt	°/₀	lbs.	cwt	°/₀	lbs.
1	—	—	—	—	—	23½	1·4	36	22	12·2	300	27	19·7	595	11	6·3	77
2	112	—	—	—	—	28½	0·8	25	28¾	11·1	357	33	23·3	831	11¼	15·4	194
3	—	—	280	—	—	35¼	0·1	3	22	25·2	620	26½	11·8	350	22	7·9	194
4	—	—	—	208	—	33¾	1·3	49	21¾	22·5	548	21½	11·4	274	16¾	8·6	161
5	—	—	—	—	230	32¾	0·4	14	22	25·9	638	24¼	10·6	287	17¾	2·7	53
6	112	—	280	—	—	33¼	—	—	23	21·4	551	31¾	11·4	405	21	2·5	58
7	112	—	—	—	280	28½	—	—	25½	14·3	408	37¾	9·7	410	18¾	1·4	29
8	—	—	280	—	280	25½	0·2	5	25¼	17·5	494	37	11·8	488	20	1·3	29
9	112	—	280	—	280	29¼	0·1	3	26½	26·7	792	38½	10·0	431	20¼	3·1	70
10	112	—	—	208	280	29	0·1	3	25¾	11·7	337	38	8·6	366	24¾	3·7	102
11	112	—	140	104	280	29¼	0·2	6	27½	19·3	594	35	10·3	403	23½	2·5	65
12	—	86	—	208	280	24¾	0·1	2	30½	16·0	546	30¼	9·0	304	19¼	4·6	99

Influence on Ribwort of Superphosphate and Kainit.—At Blencow both have almost consistently reduced the percentage of this plant, but at other places no definite tendency in any direction can be traced.

With the single exception of Kirkbampton ribwort has consistently declined in quantity before increasing dressings of Superphosphate. Varying quantities of Kainit, have, on the other hand, had no special influence.

In their effects on this plant no definite distinction can be drawn between Superphosphate and Basic Slag.

In every case Lime has increased the percentage of ribwort, the average for the four stations of Set 2 being:

General manure, without Lime, 11·5 per cent. Ribwort = 393 lbs. per acre.
„ „ with Lime, 16·6 „ „ = 518 „ „

TABLE XII.—EFFECTS OF MANURES ON RIBWORT (SET 2).

Plots.	Manures per Acre.				Brampton.			Gosforth.			Kirkbampton.			Wigton.		
	Nitrate of Soda.	Super.	Slag.	Kainit.	Yield of Hay.	Yield of Ribwort.		Yield of Hay.	Yield of Ribwort.		Yield of Hay.	Yield of Ribwort.		Yield of Hay.	Yield of Ribwort.	
	lbs.	lbs.	lbs.	lbs.	cwt	°/。	lbs.	cwt	°/。	lbs.	cwt	°/。	lbs.	cwt	°/。	lbs.
1	—	—	—	—	27¼	13·0	396	27½	9·5	292	29	27·2	883	26½	27·4	813
2	112	392	—	392	25	21·5	602	25	4·4	123	29¾	12·7	423	27	13·6	411
3	112	196	—	392	21¾	24·2	589	21	4·6	108	31¾	13·8	490	24	15·3	411
4	112	588	—	392	20¾	13·6	316	23¾	3·2	85	27¾	25·0	777	29¼	6·5	212
5	112	392	—	196	22¾	10·0	254	23	6·9	177	26¼	24·0	705	30½	19·3	659
6	112	392	—	588	25¼	8·5	240	23¼	6·8	177	30	10·2	342	33¼	7·5	919
7	56	392	—	392	30¼	11·2	379	23½	3·6	94	30¾	10·5	361	29	18·6	603
8	168	392	—	392	29¾	16·0	533	24¾	6·7	185	34	6·5	247	34½	7·5	289
9	56	—	320	392	29¼	18·2	601	23¼	5·8	151	35¼	19·4	765	34	13·2	502
10	56	—	480	392	29¾	14·4	479	21¾	5·8	141	33¼	22·3	830	38¼	13·3	569

General Conclusions.—

Nitrate of Soda when used with Phosphate has had a markedly repressing influence on *Agrostis*. Under these circumstances it has increased the yield of crested dogstail, though, when Phosphate was omitted from the dressing, it has diminished the relative yield of this plant. It has greatly added to the yield of Yorkshire fog, while it has been the means of curtailing the development of *Leguminosæ* and ribwort. Used alone, or only with Kainit, it has tended to encourage the production of an inferior type of herbage.

Sulphate of Ammonia, as compared with Nitrate of Soda, has produced more *Agrostis*, crested dogstail, and ribwort, while the reverse is the case in respect of cocksfoot and *Leguminosæ*.

Superphosphate has generally reduced the percentage of *Agrostis* and cocksfoot, while it has failed to have any general influence on the other plants.

Superphosphate, as compared with Basic Slag, produced much more *Agrostis* and less cocksfoot, while there is no consistent difference in their action on the other plants.

Kainit has exhibited a powerful influence on certain plants. It has **markedly** increased the yield of *Leguminosæ*, and almost as **markedly** repressed the growth of *Agrostis*. On the other plants, however, its action has not been conspicuous.

Lime had but little influence on the general yield, but it has **considerably** affected the growth of certain plants. It has **consistently** increased the yield of ribwort, and has markedly **reduced** the percentage of *Agrostis* and Yorkshire fog. It has **not**, however, had much influence on the growth of cocksfoot, crested dogstail, or *Leguminosæ*.

DESTRUCTION OF CHARLOCK BY SPRAYING.

An experiment on the destruction of charlock by the use of a dilute solution of Sulphate of Copper was carried out at five centres. The object of the experiment was to determine what quantity and what strength of solution was most suitable.

The following Table gives the names of the centres and other particulars:—

Centre.	Crop.	Condition of Charlock.	Date of Spraying.	Remarks.
Airey Hill, Stocksfield. (Mr. Stoker.)	Oats with seeds.	In rough leaf and very strong. A quantity of Wild Radish.	June 6th.	Rain fell in the evening. Charlock much injured but not destroyed. Plots 8 and 9 best. Plot 2 worst. Wild Radish slightly checked, not killed.
Findon Hill, Sacriston. (Mr. Holmes.)	Oats.	Coming into flower.	12th.	Weather fine. Effect immediate. Results striking. Plots 3, 5 and 8 best in order. Oat crop benefited.
Whittingham. (Mr. Arthur.)	Barley with seeds.	In rough leaf. Very thick.	13th.	Rain began to fall after 4 plots were sprayed, and work stopped. On these 4 plots Charlock was destroyed.
Wandylaw, Chathill. (Mr. Mathison.)	Oats with seeds.	Very thick. Half of it beginning to flower.	14th.	Very successful. Plot 5 best, then 3; Plot 8 next, but a long way behind others; 2 and 4 about equal to 8; 7 and 9 poorest result. All over however the Charlock was much reduced, and oats or seeds not injured.
Hedley Hall, Lamesley. (Mr. Bell.)	Barley with seeds.	In rough leaf.	16th.	Very successful. Plot 5 best, followed by Plots 3, 8, 2, 4, 7 and 9 in order. Barley and seeds not injured.

The experiment was carried out on ten plots. In most cases the plots were ⅕-acre, but the size and arrangement varied with the distribution of the charlock.

Three of the plots, Nos. 1, 6, and 10, were untreated; the others were sprayed at the following rate per acre:—

Plot.	Water. Gallons.	Copper Sulphate. Lbs.	Strength of Solution. Per Cent.
2	50	7½	1½
3	100	15	1½
4	50	10	2
5	100	20	2
7	25	7½	3
8	50	15	3
9	25	10	4

The fields treated were all very badly infested. Owing to wet weather, it was rather late in the season before the work could be taken in hand. In two cases (Airey Hill and Whittingham Inn) rain interfered to some extent with the test, but at the other centres it was successfully carried out.

The results may be summarised as follows:—

1. Charlock may be destroyed with absolute certainty by spraying with a solution of Copper Sulphate.
2. The important factors for success are (*a*) suitable weather—a calm, dry, bright day is best, and (*b*) that the charlock is of the right size. If sprayed when too small, the work is ineffective and wasteful of solution, if sprayed when too old, the weed is difficult to kill, partly because it is covered up by the corn crop. Spraying should be done after the plant is 2 inches high and before the first flowers appear. In the North of England the usual time will be between May 20th and June 10th.
3. The quantity and strength of solution must vary according to circumstances.
    - (*a*) When the weather is perfect, the charlock is of the right size, and the spraying machine is worked properly, 50 gallons water, with 7½ to 10 lbs. of Copper Sulphate, should be used.

(*b*) When charlock is exceedingly abundant, or if it is old and covered by the corn, increase the quantity of the solution to 75 or even to 100 gallons per acre, but do not increase the strength. For spraying late in the season, 100 gallons of a 2 per cent. solution was found to be most effective last year. When water cannot be readily procured, a smaller quantity of a stronger solution may be used; 50 gallons of a 3 per cent. solution is often recommended, but it did not do so well as 100 gallons of a 1½ per cent. solution in our trials.

(*c*) When the weather is damp or rain threatens, do not spray. If a machine has been borrowed, or if for any other reason it is found necessary to spray in damp weather, increase the strength of the solution, but not its quantity. From 30 to 50 gallons of water and 10 to 20 lbs of Copper Sulphate may be used according to circumstances, but it is seldom advisable to use a solution of over 4 per cent., otherwise the corn crop (especially if barley) may be injured.

EXPERIMENTS CARRIED OUT AT THE NORTHUMBERLAND COUNTY DEMONSTRATION FARM, COCKLE PARK, MORPETH.

THE INFLUENCE OF SOIL AND MANURE ON THE FEEDING VALUE OF SWEDES.

In the early months of the year 1900 an experiment was made at Cockle Park to determine:—

1. The influence of manure,
2. The effect of soil

on the chemical composition and the feeding value of Swedish turnips.

Four lots of purple-top Monarch swedes were grown for the purpose in 1899. Three of them on a poor, stiff soil in the Upper Brick field at Cockle Park and the fourth on a good loam at Longniddry in East Lothian.*

The following table gives particulars of the swedes used:—

Lot.	Grown on.	Manuring per Acre	Yield per acre.
			T. cwt.
1	Cockle Park Up. Bk. Field, Plots 1A and 2A	9 tons Fresh Dung applied in Autumn (1A) ... 7½ tons Rotted Dung applied in Spring (2A) ...	19 5
2	Cockle Park, Up. Bk. Field, Plots 8 and 8A	2 cwt. Sul. Am., 10 cwt. Super., 5 cwt. Kainit	22 2
3	Cockle Park, Up. Bk. Field, Plots 4 and 4A	7½ tons Rotted Dung with half above Artificials	23 5
4	Southfield, Longniddry, N.B.	7½ tons Rotted Dung with same Artificials as for No. 3 ...	20 13

The crops at Cockle Park were good, and the roots were quite up to the average quality of swedes grown in the district. Owing, however, to an unfavourable season the crop at Southfield was below average, and the quality (so far as could be judged from the appearance) was not so good as is usual in East Lothian.

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* The swedes were grown for the Northumberland County Council by Major Gaukrgoer, on his farm at Southfield.

Twenty-five good swedes weighing from 5 to 6 lbs. each and the same number of small roots weighing from 2 to 3 lbs. each were sampled and analysed by Mr. Collins; the composition will be found in Table XV. and remarks on the composition on p. 180. As pointed out by him the chief difference is in the percentage of sugar. The highest percentage of sugar and the lowest of albuminoids, was found in the swedes grown with artificial manures only, and the smallest amount of saccharine and most "flesh-forming" material were present in the Scotch roots. The percentages of albuminoids in the swedes grown with Artificials only and with Farmyard manure only, were practically identical, but the former had apparently ripened better and a smaller percentage of the total nitrogen was in the non-albuminoid state.

Forty sheep were carefully selected and after eight weeks preliminary feeding (six weeks outside and two weeks in the Sheep-house) they were arranged in four lots of 10 each and were put upon the experimental diet on Jan. 2nd, 1900.

Each lot consisted of four H.B. wedders, and six hoggs; the hoggs were all by a Border Leicester ram, two out of Cheviot ewes, two out of H.B. ewes, and two out of Mule ewes.*

When the experiment began the weights were:— Lot 1, 1,019 lbs., Lot 2, 1,018 lbs., Lot 3, 1,017 lbs., and Lot 4, 1,018 lbs. As the object of the experiment was to bring out any difference which might exist in the feeding value of the swedes, it was resolved not to allow the sheep any other food to begin with. In the preliminary feeding it was ascertained that each lot ate on an average about 15 lbs. per head per day and this quantity was the allowance at first. Some of the pens might have eaten a little more, but the quantity was regulated so that every lot received the same amount and so that no lot ate any more or any less than its neighbours. As a matter of fact the appetites of the different lots were very much alike until towards the close of the experiment, when the Scotch swedes, which were not quite so sweet as the others, were less readily eaten. At the end of five weeks, as the sheep were consuming much less food than was necessary from a theoretical standpoint, an addition was made to the diet and each animal was allowed ¼ lb. meadow hay and ¼ lb. decorticated cotton cake per head per day. On March 19th the cotton cake was increased to ½ lb. per head and this ration was continued till the close of the experiment on April 9th. The giving of the concentrated foods did not reduce the consumption of swedes, on the contrary, nearly one pound more was eaten per head, and the daily ration went up to about 16 lbs.

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* A "H.B." (half-bred) sheep is a cross between a Border Leicester ram and a Cheviot ewe, a "mule" or "grey-faced" sheep is a cross between a Border Leicester ram and a Blackfaced Mountain ewe.

Live Weight Increase.—

The following statement shows the increase in live weight per lot, as the result of an average consumption of 11¾ cwt. swedes, 11¼ lbs. of hay and 15 lbs. decorticated cotton cake per lot, per week.

Lot.	Manuring of Swedes.	L.W. Gain per Lot in 14 weeks.	Per Lot per Week.	
			L.W. Increase.	Profit L.W. Increase 5½d. per lb. Food @ 5s. 2d.
		lbs.	lbs.	s. d.
1	Farmyard Manure	241	17·21	2 8½
2	17 cwt. Artificials	251	17·93	3 0½
3	Farmyard Manure and 8½ cwt. Artificials	250	17·86	3 0
4	Farmyard Manure and 8½ cwt. Artificials (Scotch Swedes) ..	222	15·85	2 1

These averages indicate that the differences in the feeding value of three at least of the four lots of swedes were very slight, and a study of the gains made by each of the sheep will show that the actual difference in the fourth case is less than it seems to be.

The live-weight increase made by each sheep throughout the experiment is given in Table XVI. The animals have been arranged in order of merit, the best of each lot first and the worst last. It is very difficult to get sheep on a winter diet to thrive uniformly, and the wide difference between the best and the worst animals in each lot shows how necessary it is to employ a large number of individuals in experiments of this kind. The averaging of the results as above, although convenient, cannot be recommended, the more instructive way is to compare the lots animal by animal. If this is done it will be seen that the poor place taken by the Scotch swedes is due to the small increase made by three of the sheep.

A comparison of the gains made by each sheep leads to the conclusion that the swedes fed to Lot 2 were slightly superior to the others. Over the whole ten sheep the increase for Lot 2 is better by a fraction than for any of the others. If the best seven be compared Lot 2 increases its lead to nearly 2 lbs. per head and if the best five are compared, Lot 2 still leads.

At the end of the first month of the experiment Lot 2 appeared to be doing decidedly better than the others, and this together with the variability in the sugar content of the swedes that had been analysed led to the sampling of a large number of individual turnips and the ultimate selection of the sweetest for seed-growing (see p. 180).

Increase made by Different Breeds.—

The different breeds of sheep were evenly distributed in the above four lots, not with the object of testing the breeds, but to secure uniformity. As the feeding was very similar and as the sheep were moderately representative it may be well to note the gains made by the different crosses.

The average live weight gain per head in 14 weeks was as follows:—

16 H.B. Shearling Wedders	25·2 lbs.
8 B.L. × Mule Hoggs	24·9 „
8 B.L. × H.B. Hoggs	21·9 „
8 H.B. Hoggs	20·9 „

INFLUENCE OF MANURES ON THE COMPOSITION AND FEEDING VALUE OF SEEDS HAY.

This experiment, like the one already described, was carried out at Cockle Park in the early months of last year. The primary object was to ascertain to what extent the feeding value of clover and rye-grass hay is affected by manures. A second object was to compare the progress made by sheep fed under cover, and sheep fed in the ordinary way outside.

Forty sheep were selected and put on a preparatory diet on November 9th, 1899; on December 18th they were separated into two precisely similar lots, 20 being put into four pens in the Sheep-house, and the remaining 20 into four pens outside. The outside pens were about 20 feet by 12 feet and were slightly sheltered by the Sheep-house. Both outside and inside the sheep were littered with peat moss. The sheep in the outside pens were kept moderately dry under foot and were quite as comfortable as they would have been on a turnip field, but they were much less comfortable than those fed in the house.

On January 2nd, 1900, the sheep were weighed and arranged in four lots. Each lot consisted of 10 sheep, 5 of them (Pen A) being inside and 5 (Pen B) outside. In each pen there were 2 H.B. shearling wedders, 1 Suffolk and H.B. hogg* and 2 Suffolk and Mule hoggs.

When finally arranged the weights of the sheep in the eight pens were as follows:—

Lot.	Pen A (inside). lbs.	Pen B (outside). lbs.	Total. lbs.
1	529	530	1059
2	527	530	1057
3	528	530	1058
4	527	531	1058

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* Except in Pen 4 B where all the hoggs were out of Mule ewes.

Each of the four lots was fed upon a different quality of hay, but in other respects the food supplied to all was exactly the same.

The special hay was grown in the Tower Hill field in 1899 and references to the crop will be found in the Report of last year, pp. 40 and 110, and to its chemical composition on pp. 182 and 216 of the present Report. From these sources certain information respecting the manuring and composition of the hay is reproduced here.

Lot.	Manuring of Hay Crop per Acre.	Botanical Composition.		Chemical Composition.		
		Clover and Trefoil.	Grass.	Albuminoids.	Carbohydrates.	Woody Fibre.
1	7 cwt. Slag ... ... 4 cwt. Kainit	25·5	73·9	10·6	51·98	27·68
2	Do. with 1¼ cwt. Nit. of Soda	18·7	80·9	6·78	51·11	34·40
3	Do. with ⅞ cwt. Sul. Am.	29·1	69·9	8·68	50·20	32·34
4	Do. with 1¾ cwt. do.	19·7	80·0	5·76	52·12	33·54

The hay for Lot 1 had a higher percentage of albuminoids and less woody matter than the others, and the chemical composition indicates it to have been distinctly superior to them. The crop grown with ⅞ cwt. Sulphate of Ammonia per acre was decidedly the best of the other three.

For the first five weeks the sheep received 8 lbs. swedes per head daily and as much hay as they would eat. The average consumption per head was for Lot 1, 1·73 lbs.; Lot 2, 1·56 lbs.; Lot 3, 1·78 lbs.; and Lot 4, 1·64 lbs. The gains made on this diet were small but they indicated a considerable difference in the feeding value of the hay, and it would have been desirable to have continued it until the end of the experiment were it not that the supply of hay was limited. For this reason a choice had to be made between allowing the sheep as much hay as they could eat and terminating the test in three weeks, or restricting the hay and giving concentrated food.

The latter alternative was chosen chiefly because it was thought desirable to have some of the sheep ready for the butcher by the time that the experiment came to an end. For the last six weeks, therefore, of the period of eleven weeks over which this experiment lasted the sheep received 1 lb. hay, 10 lbs. swedes, ¼ lb. decorticated cotton cake and ¼ lb. maize meal per head daily.

After February 23rd, as the whole of the special hay had been consumed, hay grown on a plot manured with Dissolved Bones and Kainit was used for Lot 1. The chemical composition of the substitute was slightly inferior to the original, but better than that of the hay fed to the other lots of sheep.

Live Weight Increase.—

The live weight increase made by each of the lots of 10 sheep was as follows:—

Lot.	Live Weight increase in pounds per Lot.			Per Lot per week.	
	First Period 5 weeks.	Second Period 6 weeks.	Whole Period 11 weeks.	Live Weight Increase.	*Loss*, valuing L. W. increase at 6¼d. per lb., and food at 5s. 11d. per week.
				lbs.	s. d.
1	31	80	111	10·1	0 8
2	14	76	90	8·2	1 7¾
3	34	83	117	10·6	0 4¾
4	14	100	114	10·4	0 6

It will be remarked from the foregoing figures that over the whole period of eleven weeks the difference in the feeding value of the hay fed to Lots 1, 3 and 4 was not pronounced. When the sheep received concentrated food the effects of the special diet could not be measured by weighing, but at first, when the ration was restricted to hay and 8 lbs. of swedes, the influence of manures on the quality of the fodder was pretty clearly shown.

The decided inferiority of the hay fed to Lot 2, is brought out forcibly by the details given in Table XVII. It will there be seen that the low live weight gain is not due to one or two individuals, but is general. All the way down from the 1st to the 8th sheep Lot 2 is inferior to the others.

It is difficult to account for the comparatively high place taken by Lot 4. One of the sheep was exceptionally good, but this alone would not explain why the hay has given so much better results than the hay grown with Nitrate. In chemical composition it is no better, if as good, and the difference in feeding value is probably due to some difference in its digestibility. The "Nitrate" hay was apparently much riper than the other, the proportion of amide to albuminoid matter was only about 1 to 7 as against 1 to 4¾, and there was also a little more woody fibre.

Inside v. Outside Feeding.—

The last column in the summary given above shows that the diet fed to the sheep was not a profitable one. The primary object of the experiment required that the diet should be restricted and therefore not of a kind likely to lead to profit. It is instructive to compare the progress made by the sheep fed outside and inside upon this limited and, on the whole, unprofitable diet, for if this is done we find that the loss was made on the former and that the latter paid for their keep.

The total gain made by the 20 sheep fed inside in eleven weeks was 247 lbs., the gain made by the sheep fed outside in the same time was 185 lbs. At 6¼d.* per lb. the value of the mutton made inside amounted to £6 8s. 8d. and that made outside to £4 6s. 4d. The cost of feeding for eleven weeks was £6 7s. 6d., so that while on the sheep fed in the ordinary way outside there was a loss of £2 1s. 2d., the 20 animals fed inside paid for their food and left a small margin. The difference per head between the two lots of sheep amounted to about 2¼d. per week. In comparing these figures it must be remembered that the diet was not adapted to produce rapid growth and that if the sheep had been liberally fed the difference in favour of those fattened inside would presumably have been greater. Although the diet was a low one it was not in itself unfavourable to sheep fed outside. On the contrary it contained a much larger proportion of dry food than is usual, and was relatively better suited for sheep fed in the open than for animals under cover. Although on the average the sheep did best under cover a reference to Table XVII. will show that some of the best animals were found among those fed outside. The cold and discomfort that checked the growth of the "average" animal, had no apparent effect on a few hardy individuals.

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*This may seem a high price, but it will be justified later on.

In the above calculations no account has been taken of the cost of the moss litter used for bedding. The quantity necessary in a sheep-house will vary from ¾ to 1 ton per 100 sheep per month. Assuming that Dung made inside is equal in value to Dung dropped on grass or fallow by animals feeding outside, sheep which are fed under a rain-proof roof must be debited with 3d. per head per month for litter. If the roof is not water-tight a much larger expenditure will be necessary.

Gain made by the different Breeds.—

The average live weight gain made in eleven weeks by the three breeds used for this experiment was:—

16 H.B. Shearling Wedders	...	10·8 lbs. per head.
7 Suffolk and H.B. Hoggs	...	11·6 „ „
17 Suffolk and Mule Hoggs	...	9·6 „ „

Proportion of Carcase to Live Weight Increase.—

The values affixed to the live weight increase made by the sheep in these Experiments, viz., 5½d. per lb. in the first case and 6¼d. in the second, may appear to be too high. The method by which they were arrived at will now be explained.

Experiment II. finished upon March 19th, but 20 of the sheep were kept upon the special feeding until April 9th. On that day 5 representative H.B. shearling wedders were selected from each of the experimental lots and were slaughtered. These 10 sheep had been fed on Tree Field in the previous season and from September 21st until December 18th they were all treated alike. From December 18th until April 9th the diets had been those described above, 5 of them getting about 16 lbs. swedes with a small ration of dry food and other five, 8-10 lbs. of swedes with a large proportion of dry food.

The effect of the feeding upon the proportion of carcase to live weight increase is dealt with in the table on p. 121.

It has been assumed that when the sheep came off the Tree Field on September 21st the proportion of carcase to "fasted" live weight was 45 per cent. This is a liberal estimate, for, assuming that these sheep weighed as well as the best animals selected for slaughter from each of their respective plots at the close of the Tree Field experiment in 1899, the percentage of carcase to live weight would only have been 45·7. It has further been assumed that on December 18th, 46 per cent. of the "unfasted"* live weight was carcase. This also is a liberal estimate for it is about equal to 47·5 per cent. of the "fasted" weight. From September to December the animals were on low diet and were not likely to have made much mutton. The actual live weight increase in this preliminary period was 8 lbs. a head and it will be seen from the table that 5 lbs. of this increase has been estimated to be mutton. On December 18th we suppose that the 10 sheep averaged as nearly as possible 55 lbs. carcase per head. These estimates together with the live weight of the sheep on September 21st, December 18th and April 9th and the carcase weight on April 11th will be found in the following table.

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* It would have been better if the sheep had been fasted before weighing throughout these experiments, but the relative weights cannot have been much affected, for the sheep were always weighed at the same hour in the morning, and before they had eaten much food.

Live Weight and Carcase Weight (partly estimated) of 10 H. B. Shearling Wedders before and after Fattening.

	Experiment I. 5 Sheep fed on 16 lbs. Swedes and a small ration of dry food from Dec. 18th to April 9th.		Experiment II. 5 Sheep fed on 8-10 lbs. Swedes and a large ration of dry food from Dec. 18th to April 9th.	
	Live Weight.	Carcase Weight.	Live Weight.	Carcase Weight.
	lbs.	lbs.	lbs.	lbs.
Average "fasted" Live Weight and estimated Carcase Weight on Sept. 21st, 1899 (carcase 45%)	110·8	49·9	113·	50·8
Average unfasted Live Weight and estimated Carcase Weight on Dec. 18th, 1899 (carcase 46%)	118·8	54·6	121·	55·7
Average unfasted Live Weight on April 9th, and average actual Carcase Weight on April 11th, 1900	146·6	73·8	143·8	73·2
Actual Live Weight and estimated Carcase increase between Dec. 18th and April 9th	27·8	19·2	22·8	17·5
Percentage of Carcase to Live Weight increase during fattening	69·		77·	
Value of Live Weight Increase if Mutton sells at 8d. per lb.	5½d.		6¼d.	

In passing from a "store" to a moderately fat condition the proportion of carcase to live weight increase varied with the character of the diet from 69 to 77 per cent.

Mr. McBryde, who killed these sheep, expressed himself as well satisfied with the quality of the mutton. There was very little difference between the two lots but the carcases of those fed on the drier of the two diets, were considered slightly superior. There was more "sap" in the mutton. From the appearance of the sheep before killing it was expected that the mutton of the shearlings from Experiment I. would have been best.

Taking the two lots all over those fed mainly upon swedes were unquestionably the best. The whole of the sheep under the Swede-feeding Experiment, and 20 of the best that had been under Experiment II. were valued on March 31st by two experienced salesmen—the Messrs. Iveson of Hexham—the former were pronounced on the average to be quite equal to the latter, and the 20 best sheep of Experiment I. to be worth from 2s. to 3s. a head more than the 20 best of Experiment II.

Comparison of the Rations used in the Experiments.—

Although there was no intention of contrasting the two diets employed in the foregoing sheep-feeding experiments, in view of the results obtained it will be instructive to institute a comparison between them. All the 40 sheep under Experiment I. and 20 of those under Experiment II. were fed under cover at the same time and, except for the diet, under identical conditions. The sheep were of the same size and age, the shearlings were of the same breed and although the hoggs were not all of one breed, they were reared on the same ground and were quite similar in quality.

It will be remembered that after a period of preliminary dieting, the sheep under Experiment I. were allowed as many swedes as they would eat; and were found to consume about 15 lbs. per head daily. The sheep under Experiment II. received 8 lbs. swedes daily and as much clover hay as they would eat and they consumed of the latter food rather more than 1$\frac{5}{7}$ lbs. per head per day. After five weeks of this feeding more liberal dieting was resorted to and animals on the "Swede" experiment received, in addition to 16 lbs. roots, $\frac{1}{4}$ lb. meadow hay and $\frac{1}{4}$ lb. decorticated cotton cake daily, those on the "Hay" diet received 1 lb. clover hay, 10 lbs. swedes, $\frac{1}{4}$ lb. decorticated cotton cake and $\frac{1}{4}$ lb. maize meal. The average gain and the profits are shown on page 123. The profits have been estimated on the basis of the prices already given.

During the first period the gains made by the two lots of sheep were remarkably different and even if we assume that but 50 per cent. of the increase was carcase in the former case, and that all was carcase gain in the latter, the daily diet of 15 lbs. of swedes must have done more than twice as well as the diet composed of 8 lbs. of swedes and 1$\frac{5}{7}$ lb. of clover hay.

	1st Period. 5 Weeks.	2nd Period 6 Weeks.	Total. 11 Weeks.	Average Profit in 11 Weeks.	
	lbs.	lbs.	lbs.	s.	d.
Average Live Weight gain per head of 40 Sheep in Experiment I. ...	6·25	10·77	17·02	2	7½
Average Live Weight gain per head of 20 Sheep in Experiment II. ...	1·64	10·70	12·34	0	0¾

German investigations made on sheep fed with hay, indicate that animals of the size used in these Experiments would, in 35 days, have required approximately 3·7 lbs. of *digestible* albuminoids and 40 lbs. of digestible carbohydrates, fibre, etc., per head to maintain their weight.* The following table shows the *total* weight of nutrients consumed in 35 days by each animal in Experiments I. and II.

	Consumed per head in 35 days.					
	Experiment I.		Experiment II.			
	520 lbs. Swedes.		280 lbs. Swedes.		*55 lbs. Hay.	
	lbs.		lbs.		lbs.	
Albuminoids	2·9		1·6		4·4	
Amides	2·5	47·8	1·4	25·8	·5	46·3
Carbohydrates (including Pectins)	40·		21·6		28·2	
Woody Fibre	5·3		2·8		17·6	

* About 7 % has been deducted from the actual quantity supplied as an allowance for slight losses.

In a trial quoted by Warington,† sheep were proved to digest about 60 per cent. of a hay similar in composition to that grown at Cockle Park. If this coefficient is adopted and if the swedes be assumed to be entirely digested, the average consumption of digestible nutrients in 35 days would, in the case of Experiment II. amount to 3·9 lbs. albuminoids and 53·6 lbs. carbohydrates, etc. This ration exceeds the German standard for maintenance and leaves a small surplus of food for growth, so that the results obtained in our experiment are pretty much what theory would have led us to anticipate. But in the case of Experiment I. the diet, even if it were entirely digestible, was less than that usually believed to be necessary for maintenance. As it not only maintained the sheep but produced a considerable and profitable increase, we must assume that although inferior to the other from a chemical point of view, it was not from a physiological.

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* *Chemistry of the Farm*, 10th Ed. p. 146.

† *Ibid.* p. 126.

As these experiments were not designed to compare the nutritive value of hay and swedes, an attempt to calculate in exact terms the difference in feeding value of the albuminoids, carbohydrates, etc., which they contain, would be undesirable; but it may be stated with confidence, that in the case of the swedes and hay used there was a very decided difference. It should be specially noted that the hay did not do *worse* than theoretically it might have been expected to do, but that the swedes proved much *better* than those who are accustomed to employ the ordinary "feeding standards" would have expected.

One reason is this: the German "standards," on which all the "theoretical rations" used in this country are based, were chiefly derived from experiments made with hay and other foods of inferior digestibility to swedes. When indigestible foods are employed larger quantities must be fed than would otherwise be necessary, digestion involves an expenditure of energy, and this energy becomes a "first charge" upon the food. "The unequal 'ease of digestion' materially changes the nutritive value of feeding stuffs from the values which are derived simply from their chemical composition. The nutrients which are assimilated from coarse fodders yield the organism about 20 per cent. less available energy than the same amount assimilated from grain, since the coarse fodder requires so much more energy for its digestion."* This quotation refers specially to horses, but the truth it expresses is a general one, and is illustrated by the Cockle Park experiments. These experiments further throw some light on the very different estimates put upon the feeding value of swedes by different authorities. When contrasted with drier foods, their chemical composition gives them a very low place, a place which no North Countryman accustomed to feed cattle *under cover* assigns to them. The different estimates placed upon their value are usually ascribed to a variation in the composition of turnips grown in different parts of the country. This is partly the reason, but there are two others, the first of which has biassed the opinion of the practical, and the second that of the "theoretical" feeder. These reasons are: (1) because a watery food like the swede can only give the highest results of which it is capable when the animal is *warm and sheltered*; (2) because, although the digestible food contained in swedes is worth more, at any rate when used for house-feeding, than the digestible food contained in hay and straw, this fact has not been generally recognised.

The feeder wishes the fattening animal to do the minimum amount of work, and for his purpose the digestible matter of the swede would always have a higher value than the same quantity of digestible matter in hay, were it not for the large amount of water contained in the former. This decreases the value of the root crop as a food for animals exposed to cold and wet.

In the second period, the diets fed to the sheep were more liberal, and at the same time were more alike, the animals in Experiment I. getting some dry food, and those in Experiment II. receiving less hay and more roots. Assuming the foods used to have been of ordinary digestibility, both lots received almost the same amounts of digestible albuminoids and "starch equivalents." In both cases the supply was ample and upon the new fare the sheep did about equally well. As the animals were now on a full diet there was no longer a possibility of swedes proving superior as they did in the first period of the experiment.

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* Professor Zuntz, of Berlin, in the American Experiment Station Record, Vol. VII. p. 548.

Summary.—

Two attempts were made to ascertain how the feeding value of farm produce is affected by the circumstances under which it has been grown. The experiments were made on sheep. All of the animals in the first, and half of those in the second experiment were fed in the Sheep-house. The following is a summary of the facts brought to light in the course of the experiments.

(1) Between swedes grown with Farmyard manure alone, Farmyard manure and Artificials, and Artificials alone, very slight differences in feeding value were found. If an artificial manure grows and ripens a good crop of swedes, the feeding value is not likely to suffer.

(2) Swedes grown on a good soil in East Lothian proved not quite equal to swedes of the same variety grown with the same manure on an inferior soil at Cockle Park; but the latter were quite up to the average quality of the district, whereas the former were not.

(3) Of four qualities of clover and rye-grass hay tested, hay grown with 1¼ cwt. Nitrate of Soda, 7 cwt. of Slag, and 4 cwt. of Kainit per acre, proved inferior to a sample grown with Slag and Kainit only, and also to hay grown with ⅞ cwt. and 1¾ cwt. of Sulphate of Ammonia with Slag and Kainit. In this particular case the chemical and botanical analyses of the hay indicate that the inferiority was due to over-ripeness.

(4) Twenty sheep fed under cover left 2¼d. per head per week more for their keep than twenty similar animals fed outside.

(5) When sheep were fed on a diet consisting chiefly of swedes it was found that 69 per cent. of the live weight increase in passing from a "store" to a moderately fat con-

dition was carcase. When sheep were fed on a limited ration of swedes and a full supply of hay 77 per cent. of the live weight increase was mutton.

(6) The feeder who fattens cattle under cover appreciates the swede; at Cockle Park it was found that for sheep fed under cover the swede is a valuable food. Sheep fed in the house for a period of thirty-five days were allowed as many swedes as they would eat; they consumed about 15 lbs. per head per day; they gained 6·25 lbs. per head upon this diet, although it contained less nutriment than is usually assumed to be necessary for maintenance. Twenty similar sheep fed in the same house and for the same period, were allowed 8 lbs. swedes per day and as much seeds hay as they would eat; they consumed about $1\frac{5}{7}$ lbs. per head of the latter; they gained only 1·64 lbs. per head in thirty-five days, although the diet from a chemical standpoint, was more liberal than the other. This result is explained by the fact that it takes more *digestible food* to supply the animal's needs when the food is presented in a form difficult to digest—as in hay—than when in a form easy to digest—as in swedes.

THE INFLUENCE OF MANURES ON THE FEEDING VALUE OF PASTURE GRASSES.*

THE TREE FIELD EXPERIMENT.

This experiment, started in the early spring of 1897, has now reached the end of its fourth season. As the scope, objects, and conditions of the experiment have already been set forth in detail, it is now only necessary to say that the main point of novelty in connection with the work consists in this;—that whereas hitherto the effects of manures on grass-land have usually been gauged by the weight of herbage which they have produced, they are here determined by the influence which the manurial substances have—through the medium of the pasture—exerted upon the live weight of the sheep with which the plots have been stocked.

In order to make it possible to provide grazing room for a sufficient number of animals, each plot has an area of 3 acres, over and above which there is a corresponding set of sub-plots, each $\frac{1}{20}$-acre in extent, on which the herbage is converted into hay. In this way the effects of the manures are determined in terms both of animal increase and crop produce.

When the experiment was started it was uncertain whether sheep would thrive and remain sound on such a small area as a three-acre plot, but the experience of the past four years has shown that there was no need to apprehend any such difficulty. Of 359 sheep used during the four seasons for stocking the eleven plots, two have died and six have been removed owing to ailment, while one other, although not removed, exhibited symptoms in the last month of the experiments in 1900 that made it desirable to exclude it for that period from the calculations. In each case animals from the reserves have been at once substituted for those that had to be removed. There is no intention of attempting to maintain that the sheep thrive as well under the confinement of these 3-acre plots as on a larger area with occasional changes; all that is asserted is that the restricted feeding-range of the animals does not in any way interfere with health, and has but little influence on their growth. Of this ample proof is furnished by the reserve sheep, which have had practically unrestricted grazing ground, and yet they exhibit a gain that is but fractionally better than the animals on the best of the plots.

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* This account is substantially a reprint of an article by W. Somerville and T. H. Middleton, that appeared in the December part of the *Journal of the Board of Agriculture*, 1900. Reprinted by permission of the Controller of H.M. Stationery Office.

Manuring.—

The manures which have been applied to each plot from the beginning of the experiment up to the present time are specified in detail in Table XIX. The cost of the dressings applied since 1897 is calculated on the basis of the prices of that year.

It will be seen that last season Plot 4, which in 1897 got 5 cwt. of Basic Slag per acre, received a further dressing of an equal quantity of the same manure, so as to bring up the total application of Phosphoric Acid to 200 lbs. per acre, the amount originally given to Plot 3. On Plots 5, 7, 8, and 9 the Superphosphate, and on Plot 10 the Dissolved Bones, have been similarly repeated, while a supply of Nitrogen equal in amount to that contained in the Bones was given to Plot 9 in the form of Sulphate of Ammonia. A plot, No. 11, hitherto held in reserve, was added, and received Basic Slag at the rate of 15 cwt. (300 lbs. of Phosphoric Acid) per acre.

For 1900 the Basic Slag was applied on November 9th, 1899, the Superphosphate and Dissolved Bones, on March 24th, 1900, and the Sulphate of Ammonia on April 20th of the same year.

Sheep.—

One hundred and thirty half-bred wedders (out of a Cheviot ewe by a Border Leicester ram) were purchased in the south of Scotland, and reached the farm in the middle of May. They were fasted for a night, weighed, numbered, and divided into eleven lots. At the beginning of the season it was decided, in the light of past experience, to put six sheep on Plots 2 and 6, eight sheep on Plots 1 and 11, and nine sheep on each of the others. The sheep were selected so that the average weight of each lot was the same, and so that sheep of corresponding weights—above average, average, and under average—were put upon each plot.

Throughout the season the sheep grew with regularity, there were no deaths, and only one animal—on Plot 2—had to be removed owing to illness, and another substituted. In this case, as also in the case of a sheep on Plot 1, which was ill for a part of the last month, but was not removed, due allowance has been made in the calculations.

Characteristics and Results of Season 1900.—

In 1900 the experiment lasted from May 23rd until October 10th, that is, for twenty weeks, as in 1898 and 1899. The sheep were weighed at the end of each period of four weeks, after having been fasted for 12 hours.

The spring of 1900 was more backward than that of 1899, and as a consequence the plots were nearly three weeks later in being stocked than in the previous year. The first month was favourable, and the sheep made the largest weekly increase yet recorded in the course of the experiment, but the late spring involved late autumn grazing, and the falling-off in the final month, as compared with last year, was very marked. In spite of this falling off in the live weight increase, the majority of the sheep came off the experimental plots in very good condition, and fifty were selected for the fat market.

The rainfall at Cockle Park for the twenty-eight weeks ending on October 6th was:—

	Inches.
Four weeks ending April 21st	1·744
„ „ May 19th	·890
„ „ June 16th	1·750
„ „ July 14th	3·885
„ „ August 11th	3·905
„ „ September 8th	2·785
„ „ October 6th	0·975
Total rainfall for 28 weeks	15·934

The average weekly gains per head, for each month, of all the animals on the plots (including No. 11) are given in the following statement, which also exhibits the rate of growth during each of the past seasons:—

Period.	Average Weekly Gain in 1897.	Average Weekly Gain in 1898.	Average Weekly Gain in 1899.	Average Weekly Gain in 1900.
	Lbs.	Lbs.	Lbs.	Lbs.
During the 1st four weeks .	2·26	3·43	2·90	3·70
„ 2nd „ ...	2·01	3·41	2·32	1·89
„ 3rd „ ...	1·10	1·77	1·62	2·19
„ 4th „ ...	0·32	1·25	1·77	1·41
„ 5th „ ...	—	0·24 *loss*	1·35	0·81
Mean for the whole Season.	1·42	1·87	1·95	2·00

As in previous years, an experienced salesman and butcher valued the sheep at the end of the season. He drew out those which were fat, and from eight of the plots selected representative animals, which he slaughtered and reported on. A summary of the results of the experiment for 1900, and also for the three previous seasons, will be found in Tables XIX. and XX.

The main features presented by each plot are remarked on in the following notes. In all cases, unless otherwise stated, the quantities are given in terms of an acre.

Plot 1. *Residue of 5⅓ cwt. decorticated cotton-cake consumed in* 1897 *and* 1898.

The analysis made of the cotton cake showed that 5⅓ cwt. contained 42 lbs. of Nitrogen, while it may be assumed to have contained 18 lbs. of Phosphoric Acid and 9 lbs. of Potash. The effects of the residues have been very marked. In last year's report it was mentioned that the sheep on Plot 1 made a live weight increase of 106 lbs. per acre as compared with 48 lbs on the unmanured plot, while this season the respective figures are 80 and 44.

Taking both the first and the residual value of the cake into account, we find that at the end of the fourth season the net profit on the plot stands at 38s. 9d., or nearly 10s. per acre per annum. Possibly this result is somewhat helped by the fact that Plot 1 is naturally slightly better than Plot 6, though the difference in this respect is comparatively insignificant.

During the past season the sheep on Plot 1 throve well for the first two months, but they fell off considerably after August 15th, and at the end of the grazing period there was only one ready for the butcher. One sheep fell ill in the beginning of October, and at the last weighing was found to have lost 7 lbs. In calculating the increase for the last monthly period, the average gain made by the seven healthy sheep was taken as being the gain that should have been made by the sick animal.

The salesman valued the healthy sheep at 34s., and remarked that one was very good, that the remainder were useful "stores," and that the wool indicated rather a scanty food supply for the previous fortnight.

The hay crop on the $\frac{1}{20}$-acre sub-plot was inferior in quality to that on most plots, but was decidedly better than the crops on Plot 2 and 6. Sixty per cent. of the herbage consisted of *Agrostis*. The other grasses consisted chiefly of Yorkshire fog (9 per cent.) and crested dogstail (6 per cent.).

Plot 2.—*Four tons of Common Lime in* 1897.

At the end of the third season practically no benefit had been derived from this, the most costly of the applications of 1897, and instead of a profit being realized, as on other plots, there was a deficit of 50s. 5d. per acre. In the fourth season a slight improvement was noticeable, more especially in the early months, and as compared with Plot 6, Plot 2 has somewhat improved its position. But, in face of the expenditure, and of the results obtained on the other plots, it cannot be said that Lime has added to its reputation by its effect on Tree Field, and even if we accept the butcher's valuations, which are much more favourable to this plot than the weighing machine, the loss still stands at over 30s. per acre. The coarse and valueless aspect of the herbage on Plot 2 is a source of great surprise to the majority of visitors, who associate the use of Lime with "sweet" pasture and a general improvement in the land and stock. But on the poor clay soil of the Tree Field, deficient both in organic matter and Phosphates, Lime has been given an impossible task, and it is in demonstrating the uselessness of liming pastures promiscuously that this plot is so serviceable as an object lesson. The value of Lime when used as an auxiliary to a phosphatic manure will be noted further on.

One of the six sheep on Plot 2 had to be removed on August 22, when another was substituted, and the average gain made by the five healthy sheep was credited to the plot for the period that the sick animal had been off its feed.

The salesman valued the sheep on Plot 2 at 36s. They were in a thriving condition, and though none were fit to kill, they were, as a lot, better finished than those on the last plot. and they were much better than the sheep on the unmanured plot.

The hay crop on the sub-plot was poor both in quantity and quality, consisting chiefly of *Agrostis*. There was less white clover than on any except the unmanured plot.

Plot 3.—10 *cwt. of Basic Slag* (200 *lbs. Phosphoric Acid*) *in February*, 1897.

Plot 4.—5 *cwt. of Basic Slag in February*, 1897, *and again in November*, 1899.

These plots may be conveniently considered together. It will be observed that by the spring of 1900 each plot had received the same quantity of manure, which, in the one case was supplied by a single dressing in 1897, and, in the other case, in two dressings at an interval of three years.

The two original questions as between these plots were: first, in what quantity may Basic Slag be profitably employed? and second, which will pay the best in the end, 10 cwt. applied in 1897, or 10 cwt. applied, half for the crop of 1897 and half for the crop of 1900? The first three seasons gave to the former query a much more emphatic answer than was expected. The larger dressing proved to be very much the more profitable, and at the end of 1899 the net profit, as compared with the untreated land, amounted in the one case to 78s. 4d., and in the other to 30s. 3d. per acre. The answer to the second question cannot be forthcoming till the end of the sixth season, but already there are indications that the supplementary dose given to Plot 4 is producing an effect.

White clover, which was so conspicuous a feature of Plot 3 in former seasons, was not much in evidence in the spring of the present year, and it looked as if the supremacy of this section of Tree Field had come to an end, but the month of May found this plot earlier and better than any of its rivals. For the first two months it more than held its own, and at the end of the third month it was still, so far as weight of mutton went, the best plot in the field. Later on, however, it fell away and finished with a total live weight increase of 8 lbs. less than was made by Plot 4, and of 28 lbs. less than was obtained from Plot 8.

Plots 3 and 4 were both stocked with nine sheep to start with. On June 20th three additional animals were put on Plot 3, and on July 18th one additional sheep was put on Plot 4. No subsequent changes were necessary.

The herbage on these plots presented a most interesting contrast, and in the month of July it was difficult to realise that so great a difference could have followed from so comparatively slight a cause as the application of 10 and of 5 cwts. per acre of the same manure three years previously.

Plot 4 presented the characteristic appearance of land that has recently been manured with Slag, and a thick sole of white clover was conspicuous through the closely-eaten grass. Plot 3 at a little distance was much more like a meadow ready for the mower than a sheep pasture, and closer inspection showed that the dense carpet of white clover, which was so prominent in previous years, had largely disappeared, and that in its place there was a thick growth of natural grasses. The very strong growth made by the grasses (especially by crested dogstail and Yorkshire fog) accounts for the comparatively poor results got from Plot 3 in August, September, and October. As the sheep were unable to keep the grasses down in the early summer, many of them ran to seed, so that the herbage was latterly rough and somewhat inferior. To do full justice to the pasture which Plot 3 produced, it would have been necessary to graze it partly with cattle; but this, of course, would have interfered with the character of the experiment.

When we remember that in one case this is the fourth crop grown since the manure was applied, and that in the other the Slag used last autumn will not exert its full effect until 1901, the financial results obtained on both plots in the past season are most satisfactory, and the profits made compare favourably with those of previous years. The net profit is still very much in favour of the heavy dressing of Slag, being now 105s. 6d. on Plot 3, as compared with 48s. 11d. on Plot 4.

When submitted to the valuer the sheep from Plot 4 were pronounced to be in very much better "bloom" than those from Plot 3, the values affixed being 38s. and 36s. respectively. The former were more uniform, were in higher condition, and eight were selected as fat, whereas only three of the twelve from Plot 3 were fit to kill.

The difference already noted in the herbage was marked in the hay sub-plots. Three-fourths of the herbage on Plot 3 was composed of four grasses, viz.: *Agrostis* (44 per cent.), Yorkshire fog (15 per cent.), crested dogstail (10 per cent.), and cocksfoot (8 per cent.), whereas there was but 5 per cent. of white clover. The analysis of the hay of Plot 4 showed of the foregoing grasses 33, 7, 2½, and 4 per cent. respectively, and no less than 22 per cent. of white clover. The season was very favourable to the growth of clovers, and, as compared with last year, there is a general increase in the percentage of white clover; but in the past two years the percentage of white clover on Plot 3 has fallen from 14 to 5 per cent. whereas on Plot 4 the amount has risen from 16 to 22 per cent. The comparative luxuriance of the clovers on Plot 4 must not be entirely attributed to the action of the Basic Slag applied in November, 1899. The manure has helped to increase the vigour of the *Leguminosæ*, more especially in the later part of the season, but even without this supplementary dressing it was plain from the appearance of the grass land in spring that Plot 4 would, later in the season, contain much more clover than Plot 3. The striking difference is due partly to the disappearance of clover from 3, and partly to the fresh appearance of clover in 4. The result of the heavy phosphatic manuring of Plot 3 was to stimulate a more luxuriant crop of clover that the soil could long support, and the fourth season has witnessed a reaction. The clover has dwindled away, but the soil, opened by the clover roots and enriched by the clover residues, has yielded an abundant crop of grass. If this crop will maintain its quality the Slag will have worked a lasting improvement on the field.

Plot 5.—7 *cwt. Superphosphate of Lime* (100 *lbs. soluble Phosphoric Acid) in the spring of* 1897, *and again in the spring of* 1900.

Throughout the experiment the live weight gains recorded on this plot have approximated to those obtained on Plot 4, so that Phosphate in the form of Slag or of Superphosphate appears to be equally effective. On the whole the Slag has done slightly better than its rival, the total gains for the four years being 409 lbs. on Plot 4 and 400 lbs. on Plot 5.

As Slag is a cheaper source of Phosphate than Superphosphate, Plot 4 has a very decided advantage when the profits are considered. But had there been no Slag in the question a return of mutton worth 68s. 1d. for an expenditure of 36s. 4d. in Superphosphate (and this apart from any residual value) would have been entirely satisfactory.

Nine sheep were put upon Plot 5 in May, and no additions were made. The stock did exceedingly well, especially during the last three months, and the valuer considered them the best finished lot that he examined. They were not quite so big as the sheep on Plot 4, but were worth 1s. a head more for the fat market. Seven were taken as being fit to kill. The herbage in the sub-plot was of first-class quality. It contained a large quantity (20 per cent.) of meadow vetchling. The presence of so much meadow vetchling was partly accidental, the plant is one that grows in patches, and patches were numerous on the site of the sub-plot. On the whole there was very little difference to be seen between Plots 4 and 5. The former was rather greener, and especially in the month of July it appeared to carry more food for stock, but both the weights and appearance of the nine sheep on Plot 5 showed that individually they were doing rather better than their ten neighbours on Plot 4.

Plot 6.—*Unmanured.*

The results obtained from this plot were very much the same as in former years. The six sheep made an average increase of 22 lbs. each, equal to a gain of 44 lbs. per acre for the plot.

Although the sheep gained in weight they increased little, if at all, in value. They were thin-fleshed, dark-skinned, and dull-eyed, and were worth, according to the butcher, 32s. a head, or 2s. 6d. less than they cost (deducting wool) in the month of May. At that time, however, sheep were dear, and 2s. 6d. would barely cover the fall in market value between May and October.

The hay sub-plot bore eloquent testimony to the poverty of the land in its natural state, the crop consisted chiefly of the thin hard-stalked grasses *Agrostis* sp. and *Triodia decumbens.* A much heavier crop might have been cut on the pastured areas of several of the plots than on the fenced hay-plot of No. 6.

Plot 7.—7 *cwt. Superphosphate for* 1897 *and* 1900, *and* 1½ *cwt. Sulphate of Potash* (50 *lbs. Potash*) *for* 1897, *and again for* 1899.

This plot, it will be seen, has been treated in the same way as Plot 5, except that it has received liberal dressings of Potash. The heavy dressings of Potash have not benefited the land to anything like the degree that Phosphates have. Comparing Plots 5 and 7, we find that in four seasons the latter has produced 37 lbs. live weight increase more than the former. This increase, worth 11s. 7d., has been got at an outlay of 15s. 4d. on manure, so that up to the present the Potash has not paid its way. There is no doubt, however, that it has exerted an influence on the pasture, the appearance of which led to the expectation of a profit this year. It was one of the earliest plots to be ready for stock, and in the height of the season the quality of the pasture was considered to be the best in the field. Indeed, considering the appearance of the herbage, the gains made in July and August were unexpectedly small.

The butcher valued the sheep at 38s. each. Seven were very good and fit for market, while two were inferior. As a lot, they were decidedly poorer than those of Plot 5.

The hay sub-plot was very similar in appearance to sub-plot No. 5, but, as in former years, it did not yield so well. The distinguishing feature of the herbage was the comparatively large quantity (11 per cent.) of cocksfoot, which it contained.

Plot 8.—7 *cwt. Superphosphate for* 1897 *and* 1900, *and* 10 *cwt. Ground Lime for* 1897, *and again for* 1899.

This is a plot in which the interest increases each season, and this year it merits special notice, as it has produced the greatest aggregate increase of all, being 20 lbs. per acre ahead of its nearest rival, Plot 4.

It is with Plot 5, however, that we must compare it in order to ascertain the influence of Ground Lime. In 1897 Plot 8 was 13 lbs. ahead of Plot 5; in 1898, 15 lbs.; in 1899, 11 lbs.; and in 1900, 22 lbs.; so that this year the lead has been much more marked than previously, and from the appearance of the grass during the past summer it looks as if Plot 8 were going to increase its lead still further in future. So far, with 61 lbs. live-weight increase to its credit, the plot has scarcely paid for the ton of Ground Lime but it may safely be affirmed that the Lime has already justified its application.

The improvement in the pasture in the month of July was so marked that two additional sheep were put on the plot at the time of the second weighing, and so well did the land carry this extra stock that at the end of the season the average gain per head was greater than in the case of any other plot.

By the salesman the sheep were valued at 39s., and, taken as a lot, they were pronounced to be the best, although so closely followed by the sheep from Plot 5 that no difference was made in the money value. Of the eleven, ten were fit for the fat market.

Confirmation of the opinion that the Ground Lime has justified its application by its influence on the quality, if not on the weight, of produce is given by the salesman's valuation. Adopting his estimates we find that the Ground Lime has already paid, for he makes the profit at the end of the fourth season to be 17s. 2d. on Plot 5, and 19s. 1d. on Plot 8.

Plots 2 and 8 present an instructive contrast. A dressing of 4 tons of ordinary burned lime applied to the former plot has in four seasons yielded a live weight increase of 21 lbs.; while one ton of Ground Lime on the latter has improved the produce by 61 lbs. over Plot 5. In the former case the visible improvement in the pasture is slight, in the latter it is striking.

The main reason for this difference in the effect of Lime is that where used alone its action is limited by the want of Phosphates—in which the soil is very deficient—whereas in the presence of a phosphatic dressing it is able to exert its full, or nearly its full, effect. On the other hand, Phosphates used alone have not been able to exercise their maximum influence because of the want of Lime, though here the limiting action of a deficient supply of an essential element of plant food is not so conspicuous, simply because the deficiency is not so great. We have here an excellent illustration of the "Law of Minimum," the leading principle of which is that it is useless to strengthen the manurial chain if we neglect to attend to its weakest link.

There was more clover on the sub-plot than on any of the others and the percentage of *Agrostis* was low. In round figures there was an increase of 8 per cent. in the clover, and a decrease of 10 per cent. in the *Agrostis* as compared with Plot 5, noteworthy changes when contrasted with the effects Lime and Phosphates produced on Plot 2.

Plot 9.—7 *cwt. Superphosphate for* 1897 *and* 1900, *with* 97 *lbs. Sulphate of Ammonia for* 1897, 70 *lbs. for* 1898, *and* 84 *lbs. for* 1900 *(total Nitrogen* = 50·8 *lbs.).*

The use of Sulphate of Ammonia has not been profitable. The net gain of 31s. 9d. made on Plot 5, where Superphosphate was used alone, has been reduced to 12s. 3d. per acre, where Sulphate of Ammonia has been added to the Phosphate. Nor has there been any gain in the quality of the pasture; on the contrary, the herbage was scarcely so good as on Plot 5.

A light dressing of Sulphate of Ammonia may prove useful in encouraging early growth for some such special object as "early lamb," but in general its use on poor pastures cannot be recommended.

The salesman valued the sheep at 36s. 6d., and remarked that, though thriving, they wanted quality. Four only were fit to kill.

The hay sub-plot, aided by the Ammonia, carried decidedly the heaviest crop of the series, but the Sulphate has reduced the clover by a third and doubled the percentage of the inferior Yorkshire fog. There is more of the latter here than on any other plot.

Plot 10.—6 *cwt. Dissolved Bones for* 1897, *and again for* 1900 *(Total Phosphoric Acid* 200 *lbs., total Nitrogen* 33·8 *lbs.).*

The same quantity of Phosphoric Acid has been applied to Plots 9 and 10, but the former has had a half more Nitrogen. On the whole Plot 10 has done slightly better than its neighbour—a result entirely due to the last three months, but neither in the quality of the grass nor in the yield of mutton is there much to choose between them.

The salesman valued the sheep at 38s., the average being brought up by one particularly good animal. The others were a little, but not much, better than those of the last plot. Six were taken as being fit to kill.

There was considerably less hay from this sub-plot than from sub-plot 9. In quality the hay from both these plots was very much alike.

Plot 11.—15 *cwt. Basic Slag (*300 *lbs. Phosphoric Acid) in November,* 1899.

In 1897 this plot received ½ cwt. Sulphate of Ammonia, 1 cwt. Nitrate of Soda, and 10 cwt. of Common Salt per acre, and was grazed by cattle. In 1898, and again in 1899, it was unmanured, and was grazed by sheep. Having been manured in Nov., 1899, it was this season stocked with eight sheep for sixteen weeks, its treatment, in this respect, being the same as that of Plot 3 in 1897. The live-weight increase obtained was 89 lbs. per acre, small in comparison with the yields of the older plots, but satisfactory when compared with the yield obtained from Plot 3 in its first season. Plot 11 contains some alluvial soil, and is naturally a little better than Plot 6. The yields obtained in 1898 and 1899, which are given in Table I., indicate the extent of this difference in quality.

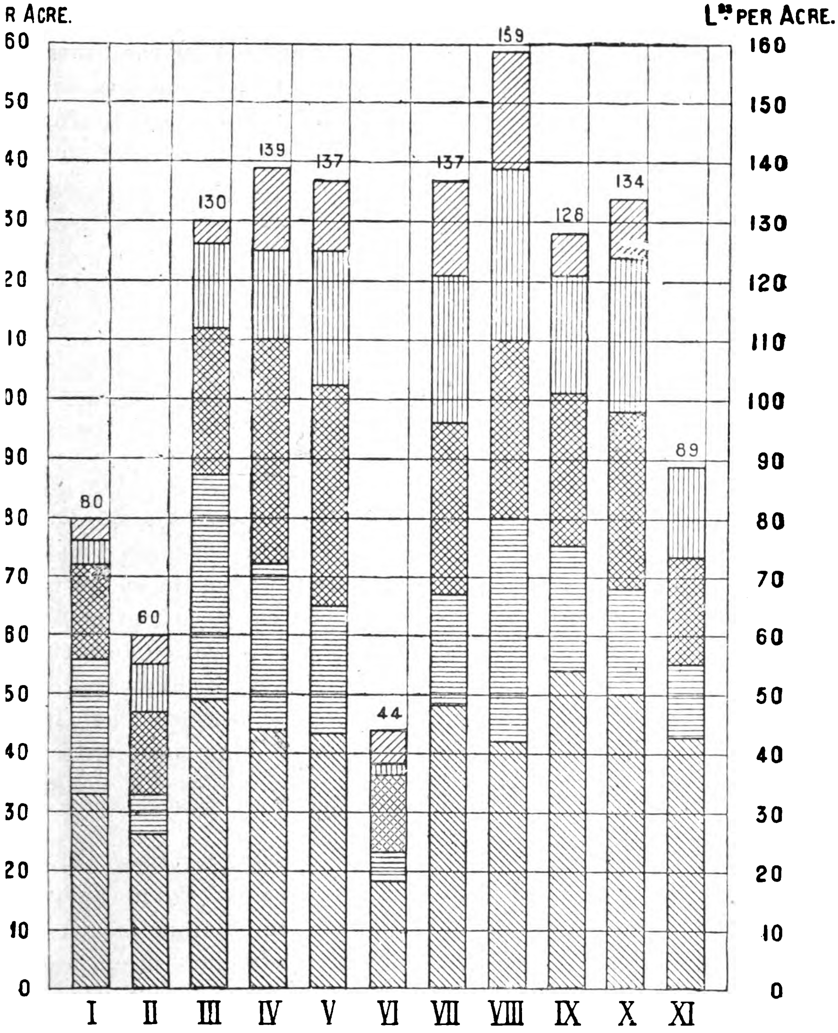
Until the end of July the effects of the Slag applied in the previous November were not marked, but thereafter white clover began to assert itself, and in the later months the clover made considerable progress.

The sheep were not submitted to the valuer, as they had been removed from the plot a month before his visit to the farm. The hay on the sub-plot, was tolerably abundant and of moderate quality. It contained 9 per cent. of white clover and also a quantity of bird's-foot trefoil.

Variations in the Plots from Month to Month.—

Periods of Four Weeks.	Plot I. Cake Residue.	Plot II. 4 Tons Lime.	Plot III. 10 Cwt. Slag.	Plot IV. 5 + 5 Cwt. Slag.	Plot V. 7 + 7 Cwt. Super.	Plot VI. Nil.	Plot VII. Super. + Potash.	Plot VIII. Super. + Lime.	Plot IX. Super. + Sulp. Am.	Plot X. Dissolved Bones.	Plot XI. 15 Cwt. Slag (1900).
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1st Period ... ... ▧	33	26	49	44	43	18	48	42	54	50	43
2nd Period ... ... ▤	23	7	38	28	22	5	19	38	21	18	12
3rd Period ... ... ▩	16	14	25	38	37	13	29	30	26	30	18
4th Period ... ... ▥	4	8	14	15	23	2	25	29	20	26	16
5th Period ... ... ▨	4	5	4	14	12	6	16	20	7	10	—
Total live weight gains	80	60	130	139	137	44	137	159	128	134	89

DIAGRAM SHOWING MONTHLY AND TOTAL INCREASE ON EACH PLOT.



The figures in Table XIX. give the sum total of the results on Tree Field, but they convey in a restricted and inadequate fashion the lessons that may be learned from an inspection of the plots. As a consequence of the different treatment which they have received, the various plots are developing very marked characters. The herbage is different and at all seasons of the year there is such a dissimilarity that it is difficult to realise that four years ago the 34-acre field was practically a uniform pasture.

The diagram upon page 143 may serve to convey some idea of the peculiarities which distinguish the different plots. It shows by means of columns how the total live weight gain per acre for each plot has been made up in the season 1900. Each column is composed of five blocks, representing the five periods of four weeks over which the experiment lasted, and the height of each block shows the gain made during the particular month which it represents.

It will be noticed that although approximately the same totals have been attained by several of the plots, the totals have been reached by quite different stages. On Plots 3 and 9, for example, the larger half of the gain was made in the first two months, while on Plots 4 and 5 the last three months contributed the larger share. Plots 4, 5, 7, and 10 kept close together all through the season, and Plot 8, which was disappointing in the first month, afterwards made, not only the largest, but, what is quite as important, the most uniform gain, thus showing that the stock were on sound, healthy food.

There may be a disposition to undervalue these minor variations, and to attribute them to accidental circumstances, but a careful examination of the pastures from month to month, and of the gains made by the individual sheep, leads us to consider them of importance. The gains made by sheep at grass are very regular and follow closely the actual condition of the pasture, and it may safely be asserted that marked differences—as, for example, between Plots 7 and 8 in the second month—were due to some specific cause.

Effect of Manures on Season of Growth.—

The results obtained on several of the plots, both this year and last, indicate that manures may affect the value of a pasture, not only by increasing the total quantity of grass, but by altering the time of growth. All the plots that have had Phosphates "come" earlier in the spring and continue to grow later in the autumn than the unmanured plot. Such a change in the season of growth necessarily follows any marked improvement such as that which has been produced by the application of Phosphates to Tree Field. But further than this, between Plot 5, which has had Superphosphate, and Plots 7, 8, and 9, which have had Sulphate of Potash, Lime, and Sulphate of Ammonia respectively, in addition to Superphosphate, there are noticeable differences in the season of growth, which are apparently due to the manuring.

This will be seen from the following tabular statement, which gives the average live weight yield per acre, and also the percentage of the yield, obtained in (*a*) the first month, (*b*) the second and third months, and (*c*) the fourth and fifth months of the seasons 1899 and 1900,* for Plots 5, 6, 7, 8, and 9:—

Plot.	Treatment per Acre.	Average Live weight increase per Acre, Seasons 1899, 1900.	Percentage of Increase obtained in		
			1st Month.	2nd & 3rd Months.	4th & 5th Months.
		Lbs.			
5	Superphosphate	120	28·8	45·2	26·0
6	Nothing	46	42·3	42·9	14·8
7	Super + Sulphate of Potash ...	122	33·9	34·3	31·8
8	Super + Ground Lime	136	25·7	41·6	32·7
9	Super + Sulphate of Ammonia...	118	36·0	38·3	25·7

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* The results of seasons 1897 and 1898 have not been included. In 1897 the grazing period extended to four months only, and in neither year were the sheep fasted before being weighed. Thus the weights got in the later months will not bear comparison with the weights of the earlier months as they do in 1899 and 1900. At the end of the first month of 1899 the sheep were weighed unfasted, but in preparing the statement a loss of 5 per cent. of the total live weight has been assumed as representing the result of "fasting," and corrections in the actual weights recorded at the end of the first month have been made.

Contrasting Plots 5 and 6, it will be observed that not only is the average yield nearly three times as great where Phosphates have been used, but that the season has been greatly prolonged, so that the sheep on Plot 5 were enabled to make 26 per cent. of the increase in the last period, as against 14·8 per cent. made by the animals on the unmanured land.

From the grazier's standpoint Plot 6 displays about as bad a state of affairs as can well be conceived. The increase is very small, and two-fifths of the entire gain is made in the first month. The mean monthly gain in the second period is just half as much as in the first; and in the third period it is one-third of that in the second. A sheep naturally gains less as the season progresses, and as the herbage becomes drier, but such a rapid decrease in the rate of growth as is here shown indicates that the animal is thriving very badly, and it is little wonder that when presented to the salesman at the end of each season, the sheep from Plot 6 are almost always valued at less than they cost, in spite of their increase in weight.

The effect of adding Potash to Superphosphate, as shown by comparing Plots 5 and 7, is somewhat remarkable. The herbage is distinctly earlier—the plots themselves, as well as the gains made by the sheep, show this—then there comes a sudden drop, so that the percentage of increase in the second period is reduced from 45 per cent. without, to 34 per cent. with, Potash. Finally there is a recovery, and Plot 7 does considerably better than Plot 5 in the later months. The great fall in the second period on Plot 7 is chiefly noticeable at the second weighing, the sheep doing badly from the middle of June till the middle of July. No peculiarity has been noticed in the pasture,* and the falling-off may be accidental, but, as it has been marked both in 1899 and 1900, this is not likely. It may be pointed out, as probably more than a mere coincidence, that the decrease takes place in the month in which meadow hay makes a large part of its growth, and that for some reason, as yet undiscovered, Potash sometimes reduces the yield of hay. It has, for example, done so on sub-plot 7 of Tree Field (see Table XX.), and on the meadow hay plots in an adjacent field (Palace Leas). In the latter case, both when used alone and when used in combination with Phosphates and Nitrogen, Potash has reduced the hay crop in thirteen out of sixteen experiments made in the past four seasons. In 1899, and 1900, to which the figures in the above table refer, the hay crop on the Palace Leas plots has, on the average of eight tests, been reduced by 12 per cent., and in no instance has it been increased.*

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* This season the pasture was not quite so abundant on Plot 7 as on Plot 5 in the month of July, but the quality of the herbage on the former plot was considered better.

Turning to the effects produced by Ground Lime, we find a very favourable state of matters disclosed by the figures in the above Table. Not only has the total yield been increased, but the rate of increase is well maintained, so that nearly one-third of the total gain is made in the fourth and fifth months. There is no sudden falling off at any part of the season. The mean monthly rate falls from 25·7 in the first to 20·8 in the second, and 16·3 in the third period. The practical result of this is that the sheep not only weigh well, but are well finished. This season the nine sheep from Plot 5 were particularly good, and were valued at the same figure as the eleven animals from Plot 8, but the butcher expressed a slight preference for the latter. Last year the sheep from Plot 8 were worth 5s. a head more than those from Plot 5.

A very interesting contrast is presented by Plot 9. Here, as the reader will have anticipated, the nitrogenous manure has quickened the growth in spring, and in the first month considerably more mutton has been produced than on Plot 5. Had fresh pasturage been available the Sulphate of Ammonia might have been distinctly useful to the stock, but under the conditions of the experiment it has proved anything but serviceable. There is a very decided falling off in the second period, and it is not followed by a recovery in the later months, as in the case of Plot 7, so that the sheep when placed before the butcher wanted "bloom," and were valued at a lower rate than their weights would have led one to expect. A reference to the column headed "Net Gain or Loss," in Table XIX., will show that the differences between the butcher's valuations and those obtained by weighing have in four seasons amounted to 14s. 7d., 14s. 11d., and 11s. 9d. respectively on Plots 5, 7, and 8; while on Plot 9 tne difference has been 18s. 9d. The butcher knows nothing respecting the treatment, or the live weight, of the animals placed before him, and he affixes a value depending on the size and quality of the sheep. These values indicate that, in his opinion, the sheep from Plot 8 are worth more per pound live weight, and the sheep from Plot 9 are worth less, than those fed on Plot 5.

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* On Plot 12 in the Palace Leas the decrease may be explained by the stronger growth of white clover induced by the addition of Potash to Phosphates; the hay on this plot though of very good quality does not weigh well.

Without attempting to draw general conclusions, it may be said that the third and fourth seasons of the Tree Field experiment clearly indicate that manures may modify the value of pasture by *affecting the season of growth, as well as by increasing the weight of produce.* Under the influence of different manures a late pasture may be made earlier, or a short-lived pasture may be induced to persist far into the autumn. There is nothing new in this assertion; most farmers who have had experience in the manuring of pastures will have remarked it, as certainly as they have noted that increased production of meat follows manuring. But just as the Tree Field experiment has afforded an exact means of determining the live weight increase due to the action of manures, so it promises to throw light on the specific effects of certain fertilisers on the quality, the earliness, and the persistence of pastures. Exact information on these points is much wanted, and the future developments of the Tree Field plots promise to be instructive.

Winter Grazing for Cattle.—

While the season's grazing with sheep is the method of testing the results that is the main feature of the experiment, it may be mentioned that at the end of the summer a considerable amount of food is still present on the plots, and, in this respect, all are not alike. This "roughness" is utilised by store cattle, with which plots are stocked in proportion to apparent requirements, and a note is kept of the duration of the respective periods of grazing.

These periods for each year are recorded in the following table in terms of "cattle-weeks," that is to say the number of weeks for which each plot would have maintained one beast. In 1899, for example, Plot 1 kept 18 cattle for 6 days, therefore one beast for $\frac{18 \times 6}{7} = 15\frac{3}{7}$ weeks, that is for 15 weeks and 3 days. The plots grazed by cattle are $3\frac{1}{20}$ acres and assuming the keep of a beast to be worth 1s. per week, the value of the grazing per acre is stated in the last column of the table.

It is noteworthy that last season there was from four to seven times more winter keep on most of the manured plots than on the untreated land.

Plot.	Periods for which the Tree Field Plots were grazed each winter in terms of "Cattle-Weeks."										Credit per Acre at One Shilling per Head per Week.	
	1897.		1898.		1899.		1900.		Total.			
	Wks	Days	Wks.	Days.	Wks.	Days.	Wks.	Days.	Wks.	Days.	s.	d.
1	18	0	9	0	15	3	8	1	50	4	16	7
2	9	0	9	0	15	3	9	3	42	6	14	1
3	18	0	27	0	10	2	18	1	73	3	23	10
4	18	0	2	4	10	2	13	3	62	2	20	5
5	18	0	14	1	10	2	11	2	53	5	17	7
6	9	0	9	0	5	1	2	3	25	4	8	5
7	18	0	20	4	15	3	13	2	67	2	22	1
8	18	0	14	1	15	3	11	2	58	6	19	4
9	18	0	27	0	15	3	11	5	72	1	23	8
10	18	0	14	1	15	3	11	5	59	2	19	5
11	...		...		...		10	4	10	4	3	6

CROP EXPERIMENTS AT COCKLE PARK.

(As a Report, by Dr. Somerville, on the first five years' experiments at Cockle Park is in course of preparation and will shortly be published, it has been decided not to submit detailed reports on these experiments at present. Tables containing the results of the experiments have been prepared and will be found in the Appendix. Brief references to them will be made below.)

Rotation Experiment.—

This experiment in Back House field came to the end of its first four-course Rotation in 1900. References to some of the results have already been made (p. 61) and details will be found in Table XXII.

The oat crop was a moderate one. It was greatly benefited by a dressing of 1 cwt. of Sulphate of Ammonia. The yield on the dunged section was much better than where Artificials only were employed.

Miniature Farms.—

The detailed results are not printed in this Report. They will appear when the first Rotation has been completed.

The hay and root crops of 1900 were very good, the corn crops were poor.

The most noteworthy feature of the season's experiment was the fine crop of turnips grown with Dung made by cake-fed cattle (for composition of this Dung see pp. 183 and 231).

Farms II. and III. are cropped on the same four-course system; the entire crop (with the exception of the barley) is consumed by cattle; the animals which consume the produce of Farm III. receive linseed cake (4-5 lbs. per head per day) the others do not; the Dung is all carefully stored in cement pits and is applied in the drill for the turnip crop. With the Dung the turnips receive 5 cwt. Superphosphate and ½ cwt. Sulphate of Ammonia per acre.

The cattle consuming the produce of Farm III. in the winter of 1899-1900 received linseed cake at the rate of about 18 cwt. per acre of turnip land.*

The yield per acre amounted to:—

Farm.		Tons.	cwt.
II.	12½ tons Dung, 5½ cwt. Artificials	19	0
III.	13½ tons Dung (with Cake residue), 5½ cwt. Artificials	26	3

In 1899, when the turnip crop was a poor one, the increase produced by the cake amounted to 17 cwt. only.

Experiment on Seeds Hay.—

This experiment was carried out upon ½-acre plots in Tower Hill field. The manuring, the weight of first and second crops of hay and the percentage of grasses, *Leguminosæ*, and weeds present in carefully sampled portions of the hay crop will be found in Table XXIII.

The objects of the experiment were:—

(1) To contrast the effects of Nitrate of Soda and Sulphate of Ammonia.

(2) To compare the effects of Slag applied in the autumn and of Superphosphate applied in the spring.

(3) To ascertain the effects of omitting Nitrogen, Potash and Phosphates in turn, from a complete manure.

The success of this experiment was marred by the weather. It was fine until the cutting of Plots 1-6B began, there was then a continuance of wet weather. The mower did not work well in the laid crop. The clovers which, owing to the delay, had become over-ripe, wasted badly in making into hay. The weights obtained from Plots 1-6B cannot, therefore, be contrasted with those from 1-6A and the comparison between Nitrate of Soda and Sulphate of Ammonia falls through.

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* If there were no losses other than from the consumption by cattle, this quantity of cake would have supplied the soil with about 100 lbs. of Nitrogen per acre.

It will be seen from the Table that the first cut of hay from Plots 1-6A was a very good one, even the unmanured land producing 47 cwt. per acre. The two complete manures produced from 4 to 6 cwt. more crop for an outlay of 33s. to 36s.

The influence of the manures on the proportion of clover and grasses, was very striking, compare for example Plots 2 and 3, and 5 and 2 in Table XXIII. With a complete manure there was 47 per cent. of clover in the hay; when Nitrate was omitted the percentage rose to 73, when Slag was omitted it fell to 30. The manures thus completely altered the character of the hay crops. In deciding upon a manure for hay the effect of the Artificials on the clovers must be carefully considered. It is important to observe not only that heavy top-dressing with Nitrate may smother the clovers out by stimulating the grasses, but that appropriate manuring with Phosphates and Potash may, by strengthening the clovers, preserve the balance of the mixture.

The Tower Hill field is surrounded by pasture land on which Slag wonderfully stimulates white clover, and one object of the experiment was to ascertain, whether on soil of this description, red clover would be more benefited by an autumn application of Slag than by a spring application of Superphosphate. The clovers in the aftermath were carefully examined by members of the Committee, and the general opinion was that though there was little difference between the effects produced by the two manures, the advantage rested with the spring sown Superphosphate. A comparison of Plots 1 and 2A with 5A proved that both phosphatic manures had markedly improved the clovers in the aftermath. The weight of the second cut of hay given in the table of results will show that if the use of Nitrate were warranted by the increase in the first cut, the increase in the second crop would pay for the Phosphates. In this particular case the mixed manure has just paid.

It may be remarked that the dressings of manure were somewhat high for the particular soil to which they were applied. The reason for this was that the hay was grown for feeding experiments and it was desirable to have its special qualities pronounced. In spite of the fact that the dressings were greater than would usually be employed on the soil, the aftermath was a fine healthy one, except where Phosphates had been omitted.

Experiment with Nine Varieties of Potato.—

On pp. 41 and 111 of last year's Report references will be found to several varieties of potato which were cultivated in the East Tower Hill field in 1899. These same varieties were again cultivated in 1900 on a piece of land close to the ground they occupied in the previous year, but of rather lighter texture. The manuring and results will be found in Table XXIV. The crop of 1899 was very good, but in 1900, although free from disease, the crop was poor.

Through the courtesy of Miss Rotheram, Principal of the Northern Counties School of Cookery, these potatoes were subjected to cooking tests on three different occasions, viz., on Nov. 23rd, 1899, on June 7th, 1900, and on March 7th, 1901. The potatoes were cooked, under the supervision of Miss Trustram, Instructress in Artizan Cookery. On the first two occasions they were judged by Miss Rotheram and on the last the work was kindly undertaken by Mr. Fulton, Potato Merchant, of Newcastle.

From five to six selected tubers of each variety were cooked. The quality of the crop of 1899 was markedly superior to that of 1900. Differences in quality were much more noticeable in November than they were after the tubers had been pitted until June. A summary showing the yield of saleable potatoes in each season, and giving notes on the cooking properties will be found on page 155. It should be not that the "order of merit" in June, refers to the quality the sound tubers which were cooked and not to the keepi properties.

For cropping qualities the "British Lion" heads the li but it is an inferior potato. It keeps well, however, and la in the season is passable. "Up-to-date" is almost as good cropper and the quality, at Cockle Park, is much better. T "Maincrop" was best in quality in 1899, but in 1900, at Cock Park as elsewhere, this was a most disappointing variety. O the two seasons the best potato for the table was "Brit Queen." The objections to this sort are, that it is liable disease and that it does not keep well. In spite of these dra backs it can be commended as a first rate potato. Sutto "Abundance," although first in quality in 1900, does not c well at Cockle Park. The only remaining variety worthy notice is "General Kitchener." This is a vigorous potato one of the best croppers; the quality is very poor when lift but it kept well last season and in summer was one of best potatoes. In March of this year the quality was very p and it cannot yet be recommended with confidence.

Experiment in Manuring Potatoes.—

This experiment was conducted in Back House field details will be found in Table XXV. The leading obje were:—

(1) To demonstrate the effects of complete and inco plete manures on the weight of the crop (compa Plots 11 to 15).

(2) To ascertain the effects of Artificials on the quality The Artificials were used in ordinary quantities on Plot 12 and in large quantities on Plots 1 to 20.

(3) To compare the results of employing Sulphate Potash, Muriate of Potash and Kainit (Plots 18 20).

QUALITY OF NINE VARIETIES OF POTATO.

Name of Variety (in order of quality in Test of 23rd Nov., 1899).	Class of Potato.	Yield per acre of Saleable Potatoes in 1899.		Remarks on Quality in Cooking Test made on 23rd November, 1899.	Condition of Potatoes on 7th June, 1900.	Remarks on Quality of Sound Tubers in Test made June 7th, 1900.	Order of Merit June 7th.	Yield per acre of Saleable Potatoes in 1900.		Remarks on Quality in Test made on March 7th, 1901.	Time required to cook, 7th March, 1901.	Order of Merit, 7th March, 1901.
		Tons.	cwt.					Tons.	cwt.		Minutes.	
Maincrop ..	Late—Kidney ..	6	6	White, floury, fine flavour, keeps colour on standing, boils, bakes, and steams well.	Good ..	Boils badly, but bakes well	7	2	13¾	Very small; boils soft	60	5
British Queen ..	Second Early—Kidney	7	13	Quality and character similar to Maincrop.	Poor; most tubers soft	Boils best; does not bake well; flavour very good	1	4	12¾	Almost equal to Abundance	67	2
Up-to-Date ..	Late—Round ..	7	17	Boils well, but not equal to above in flavour; bakes well, keeps colour on cooling.	Do., but not so bad.	Rather soft and yellow; fair flavour; bakes badly	4	5	17¾	A poor soft potato	45	4
Windsor Castle	Second Early—Round	3	10½	Boils fairly well; steamed and baked samples inferior.	Good ..	Boils very well, but not equal to British Queen; bakes well	3	3	17½	A good third ..	41	3
Sutton's Abundance	Second Early—Round	5	13¾	Boils soft, steams well.	Fair .	Moderate quality; boils soft; bakes badly	6	3	9	Best, but not a first quality potato.	46	1
British Lion ..	Second Early—Kidney	8	2	Boils badly, soft waxy dark coloured; flavour fair, steams well.	Good ..	Colour good, but boils soft; flavour moderate	5	5	17½	Very poor ..	62	7
Garton	Second Early—Round	5	10	An inferior boiling potato; flavour moderate, bakes well.	Very Fair	Boils badly; soft and waxy; bakes well	8	4	14¾	Inferior waxy potato	45	6
General Kitchener	Late—Round ..	7	17	Apppearance good, but soft, dark, waxy when boiled, flavour poor.	Good ..	Boils very well, but flavour not equal to B. Queen, and turns colour on cooling	2	4	12½	Very poor; white, soapy, flavourless	59	8
Dean Kitchin ..	Late—Kidney ..	6	0	Poor quality; dull yellow in colour, waxy.	Fair ..	Coarse, yellow, waxy	9	5	8	Very poor; yellow, coarse	44	9

The objects of the other plots will be apparent from the table which contains the scheme of manuring.

The harvesting weather was wretched, and the soil was very wet when the potatoes were raised. They were sorted into three classes and weighed. The ware and sets gathered off most of the plots were pitted. They were sorted and weighed a second time, in March.

Samples taken from the produce of certain plots were subjected to a cooking test, and portions of the samples were taken for analysis. The dry matter found in these samples is given, with the weights of produce, in Table XXV. A report on the composition and quality will be made when the analyses have been completed. In the meantime it may be observed that the excessive dressings of Nitrate of Soda and of Sulphate of Ammonia used on Plot 16 did not materially injure the quality of the potatoes; that the potatoes grown on Plot 17 (heavy dressing of Phosphates) were inferior, as were also those grown on Plot 13 (no Nitrogen), and that at Cockle Park, as at several of the Durham centres, a heavy dressing of Kainit caused early ripening and lowered the percentage of dry matter (compare Plots 18 and 20).

Experiments on the Manuring of Swedes and Yellow Turnips.—

These experiments were carried out on the E. Tower Hill. Details are given in Table XXVI. The plan and objects of the experiments were the same as for the Swede Experiment in Co. Durham, p. 9.

The most interesting result of this trial was the effect produced by omitting Potash from a mixture of manures. Cockle Park was one of two farms where the absence of Potash affected the crop to a greater extent than the absence of either Nitrogen or Phosphate. In the month of July the roots on the "No Potash" plots were not better than on the unmanured land, and at one time the plants looked like dying off entirely: but in the wet weather of August they made a wonderful overy. Aided by an abundance of moisture the roots were arently enabled to tap fresh supplies of food, otherwise y must have perished, for the effects of "potash-hunger" more acutely felt by half grown, than by young plants.

It is noteworthy that the absence of Kainit has been owed by no injurious effects on the plots that received myard manure.

umn v. Spring Manuring for Mangels.—

A ¼-acre plot in Back House field was manured in the umn of 1899 with 5 tons of moderately rotted Dung. An al weight of the same Dung was stored in the open in a l-made heap, protected with soil. This Dung was applied second ¼-acre plot early in May; it was well rotted; the ght when used was 4 tons 1 cwt. Yellow Globe mangels e sown on May 15th and at the same time the land received wt. per acre of the following artificial manures on the top the drills:— 1 cwt. Sulphate of Ammonia; 2 cwt. Supersphate; 3½ cwt. Sulphate of Potash; and 2½ cwt. Common lt. The Superphosphate was a high class one (about 35 cent.), the Sulphate of Potash was a low quality (about 11 cent. Potash). After singling both plots received a dress- of Nitrate of Soda, 1 cwt. per acre. All through the son the autumn-manured plot looked the best and the ults when lifted were:—

	Tons.	cwt.	qrs.	
. 20 Tons Farmyard Manure per acre in Autumn, with 10 cwt. Artificials	28	17	0	per acre.
. 16 Tons 4 cwt. Farmyard Manure per acre in Spring, with 10 cwt. Artificials	26	17	2	„

In the case of swedes we have always found that spring nuring gives the best crops, this is the first time the estion has been tested for mangels, the conditions for the periment were very favourable, and the autumn application oved best. The result may in part, or entirely, be due to e fact that the autumn-manured drills were not "worked" in e spring, and would, consequently, hold more moisture than ose manured in the month of May.

Effect on Barley of Manures applied to the Previous Swede Crop.—

The $\frac{1}{18}$-acre swede plots described on p. 114 of the Report for 1899 were sown with barley, and the effects on the barley crop of the manures used for swedes, were noted. Little weight can be attached to the results obtained from grain crops sown on such small plots unless confirmation of the results is got from duplicate trials, and in this case it was plain that minor differences in the soil affected the crops more than most of the combinations of manures. The only marked *consistent* effect was that produced by omitting Superphosphate from the manure for swedes. The unmanured swede crop was followed by a crop of 18¼ bushels barley, swedes receiving 2 cwt. Sulphate of Ammonia, and 5 cwt. Sulphate of Potash by a crop of 23¾ bushels barley, and swedes receiving these manures with an addition of 5 cwt. Superphosphate by a crop of 31¼ bushels of barley. Increasing the Superphosphate to 10 cwt. per acre did not improve the barley crop. Omitting Sulphate of Ammonia and Sulphate of Potash from the swede manures was not in either case followed by any regular improvement, or falling off in the barley.

Experiment on the Prevention of "Finger and Toe."—

The turnip crop of 1896 in Back House field was badly affected by the disease known as "Finger-and-toe" or "Grub," and with the object of testing the effects of certain preventative measures five ⅛-acre plots were laid out. They were treated as indicated in the following table, which shows the results of the treatment upon the swede crop of 1900.

The swedes were counted on a portion of the ground and from this it was estimated that if there had been no disease there would have been about 20,000 plants to the acre. Upon this number the percentages given in the second half of the table have been based. The great majority of the roots which were altogether destroyed, were killed off by "Finger-and-toe" but, to a small extent, insect ravages were responsible for their disappearance.

Plot.	Treatment.	Weight per acre.				Percentage.			
		Sound.		Diseased.		Sound.	Diseased.		Destroyed.
		Tons.	cwt.	Tons.	cwt.		Slightly	Badly.	
1	2½ tons Common Lime, applied 8th Nov., 1899, before the stubble was ploughed	15	11¾	1	13½	70·8	8·0	2·2	19·0
2	2½ tons Common Lime applied 17th Feb., 1897, before ploughing ...	20	11	0	13½	89·9	3·5	1·4	5·2
3	Nothing	13	18	2	17	58·4	13·8	4·7	23·1
4	5 cwt. Copper Sulphate applied 17th Feb., 1897, before the land was ploughed...	12	16¼	2	6¾	55·1	9·8	4·1	31·0
5	10 cwt. Ground Lime applied 17th Feb., 1897, before the land was ploughed...	11	9½	2	3¼	48·8	6·8	6·1	38·3

Plot 1 was very distinctly inferior to Plot 2. The contrast between Plots 2 and 3 was remarkable, the crop on the former was strong, vigorous and regular.

The ground was all badly affected, but not all equally affected by the disease and this explains why Plots 4 and 5 were rather worse than the untreated plot. The dressings used for them were apparently too small to be of any value.

The experiment proves clearly that a dressing of 2½ tons of lime applied to the soil soon after the removal of the diseased crop in February, 1897, was very much more effective than a similar dressing applied to the stubble in 1899. The former application secured practical immunity from the disease.

Farmers whose land is affected by "Finger-and-toe," are recommended to apply (according to the soil and the virulence of the attack) from 2 to 4 tons per acre of Common Lime, as soon as possible after the diseased crop has been removed.

Experiment in the Manuring of Old Land Hay.—

This experiment on the manuring of "Old Land," or Meadow Hay, in Palace Leas, comprises twenty-six plots. With four exceptions (Plots 17-20, which are ¼-acre) each plot measures half an acre. The scheme of treatment and the results are given in Table XXVII. It may here be pointed out that the plots are arranged in four groups, viz.:—

I. Plots 1-5.—**Farmyard Manure alone, and with Artificials.**
II. „ 7-16.—**Artificial Manures in different combinations.**
III. „ 17-20.—**Autumn and Spring Manuring.**
IV. „ 21-26.—**Effects of the Turf Plough.**

The treatment of Plots 17-20 was modified for the crop of 1900.

What Proportion does Hay bear to the Weight of Green Herbage?—

This is a question of some interest to those who make experiments on hay. The proportion is very variable, as the following results of a few tests made last season, will show. In the first case, that of the Palace Leas hay, the figures were obtained by carefully sampling the green herbage and drying first under cover and finally in the sun. Each sample consisted of about 20 lbs. of grass. In the other instances the entire crop cut from each plot was weighed green, and was again weighed after drying sufficiently to stack.

The following was the percentage of hay from green herbage on certain plots in Palace Leas in 1900:—

Plot	6.—Poor thin crop	33·4	per cent.
„	7.—Fair crop; grasses predominating	36·9	„ „
„	8.—Clovers much more abundant than on above plots	28·6	„ „
„	9.—Poor thin crop	32·9	„ „
„	10.—A heavy crop of watery grass and clover ...	28·1	„ „
„	11.—A poor thin crop	31·8	„ „
„	12.—A thick crop full of clover	31·7	„ „
„	13.—A mixed crop, rather over-ripe	37·2	„ „

The chemical composition of the hay is given in Table XXVIII. A botanical separation was not made in 1900. The figures obtained in the separation of the crop of 1899 will be found at p. 109 of last year's Report.

In the Tower Hill hay, Cockle Park (Table XXIII.), the aftermath of Plot 6A was full of clover, that of 1B, the adjacent plot consisted chiefly of grass. Similarly at Peepy (Table VII.) in the aftermath of Plot 5 there was an abundance of red clover, but the aftermath of Plot 10, on land that has had no manure for seven years, consisted of short hard rye-grass. The percentages of hay to green grass in these cases were:—

Cockle Park.—Plot 6A.	Clover abundant	30	per cent.
„ „ „ 1B.	Grasses strong	42	„ „
Peepy „ 5.	Clover plentiful	29·4	„ „
„ „ 10.	Clover scarce; grasses thin and dry	60·4	„ „

In May, 1897, some small plots* (25 square yards each) were laid down with various grasses, at the rate of 10,000,000 germinating seeds per acre, and the land was suitably manured. Hay has been made each year. In 1900 the grass was cut on each plot as it became ready for harvesting and was carefully dried; the following results were obtained:—

	Grass. lbs.	Hay. lbs.	Per cent of Hay.
Cocksfoot	134½	44	32·6
Timothy	93	34½	37·1
Perennial Rye-grass ...	70	32	45·7
Hard Fescue	63	25	39·6
Meadow Fescue	67	23	34·3
Meadow Foxtail	60½	19½	32·2
Crested Dogstail	16	9	56·2

The amount of hay that may be made from grass depends greatly on the stage of ripeness of the latter, but in cases where the grass is cut at the proper time, it will furnish a much greater proportion of hay if composed of such plants as rye-grass and dogstail, than if of clover and soft leafy grasses like meadow foxtail.

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* In the Experimental Garden at the College.

EXPERIMENTS CARRIED OUT AT THE CUMBERLAND AND WESTMORLAND COUNTY COUNCIL FARM, NEWTON RIGG, PENRITH, DURING THE YEAR ENDING, DECEMBER 31st, 1900.

By Mr. W. T. Lawrence.

CROP EXPERIMENTS.

Meadow Hay.—

The objects of these trials were (1) to show the most effective manuring in the year of application, and (2) the relative residual effects during the following two years. The dressings applied were those that had proved good hay manures in the experiments that have been so widely carried out in the North of England during the last nine years.

The following table shows the results per acre for each year, of the manurial dressings given to the plots three seasons ago:—

Plot.	Manure per Acre in 1898.	Cost of Artificials.		Hay in 1898.	Hay in 1899 (no Manure).	Hay in 1900 (no Manure).
		s.	d.	Cwt.	Cwt.	Cwt.
1	No Manure	...		33	31	26¼
2	10 tons Dung (no Artificials) ...	...		48½	43	33
3	¾ cwt. Nitrate, 1½ cwt. Kainit, and 3 cwt. Basic Slag	15	10	49	33	29
4	¾ cwt. Sulphate of Ammonia, 1½ cwt. Kainit and 3 cwt. Slag	17	6	43½	36¼	29
5	¾ cwt. Nitrate, 1½ cwt. Kainit, and 3 cwt. Superphosphate	16	11	53¼	37¼	33
6	¾ cwt. Sulphate Ammonia, 1½ cwt. Kainit, and 3 cwt. Superphosphate	18	6	44¾	37½	32
7	Same as rest of Meadow, viz., 15 tons Dung	...		56	46	15 tons Dung again 39¼

It will be seen (1) that the dressings containing Nitrate of Soda beat those containing Sulphate of Ammonia the first year, whereas the Sulphate of Ammonia beat the Nitrate the second year, more particularly when in combination with Basic Slag, and in the third year they stand practically on an equality (compare Plot 3 with 4 and 5 with 6). (2) That on this particular land Superphosphate as a source of Phosphoric Acid produces a heavier crop of hay than Basic Slag in all three years (compare Plot 3 with 5 and 4 with 6). (3) That all the dressings leave a considerable residue even for the third year (compare the third year's yield of each with the yield of Plot 1). (4) That though ten tons of Farmyard manure (an ordinary dressing) was easily beaten the first year by the artificial mixture given to Plot 5, yet it left a residue for the second year which greatly exceeded anything left by either of the artificial mixtures; in the third year, however, it shows little or no residue over the dressings of Plots 5 and 6.

It would appear from these interesting results that the available Nitrogen in all the dressings (Dung included) was so far exhausted by the third year as to leave them all pretty much on "all fours," but that there still remained residues of mineral manures (Potash and Phosphate). The meadow was dressed in 1898 and 1900 with about 15 tons of Farmyard manure per acre, and with what results may be seen from Plot 7; the present year's crop was somewhat disappointing where dunged, and this was due to the "flushed" grass being severely nipped by late June frosts and so prevented from attaining its usual length. As will be seen from the unmanured plot (Plot 1), this year was a much poorer hay year than either of its two predecessors.

Potatoes.—

The following table gives the results of the variously manured potato plots for the past four seasons. The potatoes have followed lea oats each year, and there is, after allowing for the difference of soil in the four fields, and the differences of season, such a consistency in the results that we are warranted in drawing some very definite practical conclusions. The quantities are per acre; the variety grown in 1897 was "Bruce," and in 1898, 1899, and 1900, "Up-to-date":—

Plot.	Manurial Dressing per Acre.	Cost of Artificials.	Yield 1900.	Yield 1899.	Yield 1898.	Yield 1897.
		s. d.	T cwt.	T. cwt.	T. cwt.	T. cwt.
1	No Manure	...	5 19	5 7	8 1	7 8
2	1¼ cwt. Nitrate, and 4 cwt. of Superphosphate	20 0	...	...	..	7 8
3	1¼ cwt. Nitrate, 2 cwt. Kainit, and 4 cwt. Superphosphate	26 0	8 3	6 16	11 1	8 19
4	1¼ cwt. Nitrate, 4 cwt. Kainit, and 4 cwt. Superphosphate	32 0	9 8	7 14	12 0	8 11
5	Half the Artificials of Plot 4, and 6 tons of Dung	16 0	9 5	10 7	12 14	9 0
6	12 tons Dung (no Artificials) ...	...	9 15	10 8	13 3	9 5
7	12 tons of Dung, and half the Artificials of Plot 4	16 0	9 9	...	...	...

As the potato is a great potash feeder, a special feature of the experiments has been to determine the quantity of Kainit (a Potash manure) that should be included in the artificial mixture. In 1897, on Plot 2, it will be seen that Kainit was omitted altogether, as many clays and clay loams (Newton Rigg soil is a good clay loam) contain naturally a considerable quantity of Potash, but with disastrous results, the yield being no greater than that of Plot 1—the unmanured plot. Plots 3 and 4 have had to decide whether 2 or 4 cwt. of Kainit per acre should be used, and the answer is decidedly in favour of of 4 cwt., for on an average over £2 worth of potatoes more have been produced by the outlay of 6s. for the extra 2 cwt. of Kainit.

The potato likes a soil rich in vegetable matter, and consequently Farmyard manure, which supplies an abundance of this, as well as the necessary plant food, is found to be the best potato manure (compare Plot 6 with the others); but where land is naturally rich in organic matter, which is indicated by its dark colour, as large a crop may be grown with the artificial dressing of Plot 4, and of perhaps better quality. This explains the reason why the best crops of potatoes are often grown with Artificials on broken lea of two or three years' standing; and also the reason why at Newton Rigg the yield of Plot 4 fell so far behind Plots 5 and 6 in 1899, and so near them in 1900. The field in which the potatoes were grown in 1899 is the reddest and most gravelly on the farm; while the potato field of 1900, has the darkest soil, that is, contains much more humus or decayed organic matter.

On any soil it would be good practice in any season to follow the manuring of half Dung and half Artificials adopted on Plot 5. This year a full dressing of Dung was supplemented by a half dressing of Artificials (Plot 7) in order to see whether a profitable increase would be produced, but the result shows no improvement on the full dressing of Dung alone.

The practical conclusion to be drawn from these repeated trials is, therefore, that the farmer should choose his manurial dressing for potatoes from those applied to 4, 5, and 6 according to circumstances. Where Muriate of Potash or Sulphate of Potash is used instead of Kainit, a quarter of the weight of either of them will supply about the same quantity of Potash as the Kainit.

This has been a bad potato year, although at one time the crop looked so promising; as much as half the yield on all the plots were "smalls" and diseased.

Mangolds.—

The following table exhibits the results of the manurial trials from 1897 to the present year. The weights and costs are given per acre. The variety is "Yellow Globe":—

Plot.	Manurial Dressing per Acre.	Cost of Artificials.	Yield 1900.	Yield 1899.	Yield 1897.
		s. d.	T. cwt.	T. cwt.	T. cwt.
1	No Manure … … … …	…	9 15	9 4	6 7
2	2 cwt. Nitrate, 2 cwt. Kainit, 2 cwt. of Superphosphate	28 0	…	…	18 8 (without Salt). 17 0 (with 2 cwt. Salt).
3	2 cwt. Nitrate, 2 cwt. Kainit, and 4 cwt. Superphosphate	33 0	…	…	19 1
4	3 cwt. Nitrate, 2 cwt. Kainit, and 4 cwt. Superphosphate	41 6	28 17	26 12	20 9
5	3 cwt. Nitrate, 2 cwt. Kainit, and 4 cwt. Basic Slag	39 6	30 1	26 14	…
6	3 cwt. Sulphate Ammonia, 2 cwt. Kainit, and 4 cwt. Superphosphate	43 0	…	20 17	…
7	3 cwt. Sulphate Ammonia, 2 cwt. Kainit, and 4 cwt. Slag	41 0	27 10	…	…
8	Half the Artificials of Plot 4, and 10 tons of Dung	20 9	31 9	30 0	18 1
9	20 tons of Dung (no Artificials) …	…	28 7	28 14	16 8
10	20 tons Dung, and half the Artificials of Plot 4	20 9	31 18	…	…

At the outset it may be remarked that each dressing has paid handsomely for itself, and of all farm crops grown none proves so near a failure on unmanured land as the mangold (see Plot 1). In 1897, Plots 2, 3, and 4 were intended to decide whether 2 or 3 cwt. of Nitrate of Soda and 2 or 4 cwt. of Superphosphate per acre should be used, and the results show that the heavier dressing of each, as given to Plot 4, was the most profitable. The same trial was repeated in 1898, but the mangold crop ("Long Red") of that year was so "gappy" from insect and rook ravages that it was useless to weigh the crop for purposes of comparison of plot with plot; but judging from the appearances of the roots of each plot as they lay pulled on the ground, Plot 4 bore again decidedly a heavier crop than either Plot 2 or 3. The dressing of Plot 4 has, therefore, since been regarded as a good standard artificial dressing for mangolds without Dung. In comparison with Plot 9, which received the heavy dressing of 20 tons of Dung to the acre, it has on the whole done quite as well. Plot 8, with 10 tons of Dung, and half the Artificials of Plot 4, has, however, certainly proved the best mangold dressing. It is possible that if half of the heavy dressing of Dung given to Plot 9 had been ploughed in on the stubble and only the other half had been put in the drills in Spring, Plot 9 might have come out first. As the mangold crop is not consumed on the land where grown, it follows that the land will be in much worse condition for the succeeding corn crop when the mangolds have been grown with Artificials alone than when Dung has been used; hence the importance of dunging this crop. In 1899 and 1900 Basic Slag has been tried against Superphosphate as a source of Phosphoric Acid, and with success, for at less cost we get a slightly increased yield (compare Plots 4 and 5). Also Sulphate of Ammonia has been tried against Nitrate of Soda as a source of Nitrogen, but with reduced yields as a result, and the dressing costs somewhat more. The difference, however, is not so great when Slag is used in combination with Sulphate of Ammonia instead of Superphosphate (compare Plots 4 and 6 in 1899 and 5 and 7 in 1900). This supports the teaching that lime is essential to the necessary changes which Sulphate of Ammonia has to undergo in the soil before it becomes an available plant food, for Basic Slag contains lime in the active state, whereas Superphosphate does not. It should, however, be remembered that Slag must not be mixed with Sulphate of Ammonia before being applied, or there will be a rapid escape of Ammonia; they should be sown separately. Plot 10 seems to show that though the crop is slightly increased by the addition of Artificials to 20 tons of Dung, it is at a loss compared with Plot 8, where the same Artificials are added to only 10 tons of Dung.

As the mangold contains a large percentage of Sodium and Chlorine—the elements which compose common salt—and as Salt has sometimes been found of value as a mangold dressing, it was tried on Plot 2 in 1897, but with the result that the crop was diminished by nearly 1½ tons to the acre; it would appear to be quite unnecessary where Kainit, which contains salt, is used; possibly unnecessary under any circumstances in the west coast counties of Britain and Ireland with their prevailing south-west winds from the Atlantic. All things considered, the use of the dressing given to Plot 8 would be the most economical and would be good farming.

It should be mentioned that where Nitrate of Soda has been used, half of it has been applied as a top dressing after the plants have been "singled"; all other Artificials have been sown in the drill just before drilling the seed.

Swedes.—

The following Table shows the results of the manurial trials in swede-growing since 1896, excepting those of 1899, in which year the crop was half a failure at Newton Rigg, as elsewhere, and no weighings were made.

So far as this year (1900) is concerned, it will be noticed that it has not only been a good turnip year, but one highly favourable to the action of artificial manures, they for the first time beating Dung. As a contrast to this the season of 1898 was more favourable to Dung than to Artificials. Just as Nitrogen is the dominant food for mangolds and Potash for potatoes, so Phosphoric Acid is the dominant turnip food; for this reason 5 cwt. of Superphosphate (a purely phosphatic manure) was used alone to Plot 2, and, as will be seen by comparing it with the unmanured plot, with marvellous effect. It has, however, paid well to add Nitrate of Soda (Nitrogen) and Kainit (Potash) to this quantity of Superphosphate (compare Plots 2 and 3), though it has been no improvement to increase the Superphosphate to 7 cwt. (see Plots 3 and 4 for 1897). As a source of Phosphoric Acid to the swede crop there appears to be little to choose between Superphosphate and Basic Slag (compare Plots 3 and 6 in 1898 and 1900), though where land is prone to "Finger-and-toe" it is safer to use the alkaline Slag than the acid Superphosphate. As a source of Nitrogen to the swede crop, on the whole Nitrate of Soda is more profitable than Sulphate of Ammonia (compare Plots 6 and 8 in 1900, and Plots 3 and 7 in 1898). As Dissolved Bone is with many north country farmers a more favourite source of Nitrogen and Phosphoric Acid than mixed Nitrate and Superphosphate, equal money values of these manures were tried in 1896 (see Plots 3 and 5), slightly to the disadvantage of the Dissolved Bone.

Plot	Manurial Dressing per Acre.	Cost of Artificials.		Yield 1900.		Yield 1898.		Yield 1897.		Yield 1896.	
		s.	d.	T.	cwt.	T.	cwt.	T.	cwt.	T.	cwt.
1	No Manure	...		9	19	11	11	18	3	9	8
2	5 cwt. Superphosphate ...	12	6	26	2	...	...	...	...	...	...
3	1 cwt. Nitrate, 2 cwt. Kainit, 5 cwt. Superphos.	27	6	29	13	23	5	26	9	22	2
4	1 cwt. Nitrate, 2 cwt. Kainit, and 7 cwt. Superphos. ...	32	6	...	...	...	...	26	6	...	...
5	4 cwt. Dissolved Bone and 2 cwt. of Kainit	27	6	...	...	...	...	...	...	21	10
6	1 cwt. Nitrate, 2 cwt. Kainit, and 5 cwt. Basic Slag ...	25	6	28	19	25	0	...	...	...	...
7	1 cwt. Sulph. Am., 2 cwt. Kainit, 5 cwt. Superphos.	28	6	...	...	24	2	...	...	...	...
8	1 cwt. Sulph. Am., 2 cwt. Kainit, 5 cwt. Slag	26	6	27	12	...	...	...	...	...	...
9	Half Artificials of Plot 3 ...	13	9	...	...	22	7	24	17	...	...
10	6 tons of Dung only	...		...	...	25	11	25	0	...	...
11	Half Artificials of Plot 3, and 6 tons of Dung	13	9	29	0	26	17	25	19	22	19
12	12 tons Dung (no Artificials) ...	...		27	7	28	12	30	0	22	16
13	12 tons Dung and half Artificials of Plot 3	...		28	2	...	...	...	...	...	...

Taking the average of the four years, a dressing of 12 tons of Dung has produced the greatest weight of crop though it has been beaten twice by the dressing of half Dung and half Artificials (compare Plots 11 and 12), and once by the Artificials of Plots 3 or 6. Where the swedes are all to be carted off the land for consumption by cattle, there can be no doubt that the full dressing of Dung is much the best for the following crops of the rotation, but it will probably be at the expense of the meadows. Where a portion of the crop only is to be taken away, and the remainder (say half a crop) consumed on the land where grown, it would be the best all-round farming, taking both arable and grass land into account, to use the half and half dressing of Plot 11 for the swede crop; and on light land where all the swedes are to be consumed on the land by sheep it might be the best farming to grow the roots with the artificial dressing of either Plots 3 or 6 and apply all the Dung to the grass land.

Plot 13 shows that it is not profitable to add Artificials to a full dressing (12 tons) of Dung.

The crops obtained in 1897 and 1898 by a half dressing of Artificials on Plot 9 and a half dressing of Dung on Plot 10 are certainly surprisingly large, and they go to show that it is the first half of a profitable full dressing that gives by far the greatest margin of profit; though it may be fairly assumed that these light dressings were greatly helped by the good condition of the land in those years, and especially in 1897 (see Plot 1 unmanured of 1897 and 1898).

Oats.—

Five different varieties of oats were grown on equal areas (¾ acre each) side by side in the same field, with the following results per acre:—

Variety.	Total Weight when Carried.			Weights when Threshed.								
				Corn.			Straw.			Chaff, "Shorts" and Loss.		
				Good Grain in Bushels of 42 lbs.	"Seconds."							
	C.	q.	lbs.		St.	lbs.	C.	q.	lbs.	C.	q.	lbs.
Hamilton ...	34	2	19	32¼	14	9	16	0	0	5	0	5
Newmarket (Webb's)	38	1	7	41¾	10	13	16	0	11	5	0	25
BlackTartarian (Webb's)	42	2	9	49	14	4	17	0	9	5	1	15
Tartar King (Garton's)	42	1	9	50½	5	2	16	1	20	6	0	0
Waverley (Garton's)	46	3	17	53½	11	3	19	1	13	6	0	12

NOTE.—"Tartar King" ripened at least 10 days before the other varieties.

SHEEP FEEDING EXPERIMENT.

On October 23rd 60 half-bred Cheviot and Border Leicester lambs in good condition were divided into three equal lots, and weighed. Twenty were penned on yellow turnips and received in addition to the turnips ½lb. of linseed cake and ¼lb. of oats per head per day with hay ad. lib.; 20

1st 7 Weeks.	Lot 1. On turnips with cake, corn, and hay.		Lot 2. On grass with cake, corn, hay, and turnips.		Lot 3. On turnips with hay only.	
	Stones.	lbs.	Stones.	lbs.	Stones.	lbs.
Total weight at commencement ...	118	2	125	0	126	7
Average weight per sheep... ...	5	12·7	6	3·5	6	4·55
Total weight at end of 7 weeks ...	134	0	137	10	132	0
Average weight per sheep	6	9·8	6	12·4	6	8·4
Total gain in 7 weeks	15	12	12	10	5	7
Gain per head per week		1·6		1·27		0·55
Next 3 Weeks.					Cake and corn added.	
Total weight at end of 10th week	140	0	143	0	138	7
Average weight per sheep... ...	7	0	7	2·1	6	13
Total gain in 3 weeks	6	0	5	4	6	7
Gain per head per week in 3 weeks		1·4		1·23		1·52
Gain per head per week in 10 weeks		1·53		1·26	...	...
Next 3 Weeks.					On grass with cake, corn, hay and turnips.	
Total weight at end of 13th week	...	...	...	...	143	1
Average weight per sheep... ...	...	...	...	...	7	2·15
Total gain in 3 weeks	...	...	...	...	4	8
Gain per head per week in 3 weeks	...	...	...	...		1·07

were placed on grass where they received the same allowance of cake and corn, hay ad. lib. and turnips ad. lib. carted to them. The third 20 were penned on turnips and received hay ad. lib. but no cake and corn. At the end of 7 weeks they were again weighed, after which, Lot 3 was allowed the same quantity of cake and corn as Lots 1 and 2. At the end of 3 weeks they were again weighed, and here the experiment with Lots 1 and 2 ended; but Lot 3 was now taken off the turnip land and placed on grass for 3 weeks, receiving cake, corn, hay and turnips as Lot 2 had done. The results are given on the preceding page.

The sheep sold for £24 more than they cost and if this sum be apportioned to the three lots proportionately to their respective gains in weight the pecuniary return for food consumed is obtained. This money-value of increase is given below, side by side with the cost of food. The value of the turnips is determined by charging Lot 3 threepence per head per week for the turnips they consumed (10 drills) while receiving hay only with them, and charging the other lots at the same rate per drill, the crop being a very even one.

	£	s.	d.	Value of increased Weight.
Lot 1 consumed in 10 weeks:—				
694 lbs. of linseed cake @ £8 per ton	2	9	7	
347 lbs. of oats ... ... ,, 8¼d. per st.	0	17	0	
452 lbs. of hay ... ... ,, 4½d. ,, ,,	0	12	1	
11½ drills of turnips	2	0	0	
	5	18	8	9 5 11
Lot 2 consumed in 10 weeks :—				
The same weight of cake and corn	3	6	7	
370 lbs. hay @ 4½d. per stone ...	0	9	11	
8½ drills of turnips...	1	9	7	
	5	6	1	7 13 0
Lot 3 consumed in 7 weeks :—				
590 lbs. of hay at 4½d. per stone ...	0	15	10	
10 drills of turnips	1	15	0	
	2	10	10	2 7 0

		Value of increased weight.
In next 3 weeks:—		
127 lbs. of hay @ 4½d. per stone ...	0 3 5	
3½ drills of turnips	0 12 2	
210 lbs. cake @ £8 per ton	0 15 0	
105 lbs. oats @ 8¼d. per stone ...	0 5 2	
	1 15 9	2 15 3
In next 3 weeks:—		
210 lbs. cake and 105 lbs. oats ...	1 0 2	
213 lbs. hay @ 4½d. per stone ...	0 5 8½	
2 drills of turnips	0 7 0	
	1 12 10½	1 18 10
		24 0 0

The whole period was a very wet one, and the land a clay loam—conditions about as bad for turnip-feeding on the turnip land as could well have been; and yet Lot 1 thus fed, very decidedly beat Lot 2, receiving the same foods on sound grass land, Lot 1 gaining rather over 1½lbs. per head per week, while Lot 2 gained rather over 1¼lbs. Lot 3 while receiving hay only, on the turnips, gained very little over ½lb. per head per week and failed to pay for their keep; and yet it was not the fault of the sheep, for as soon as they received cake and corn extra, they too gained a trifle over 1½lbs. per head per week; but fell back to a fraction over 1lb. per head per week when supplied with turnips *on grass*.

In this experiment we have three *different* lots of sheep fed in three different ways, and the *same* lot of sheep fed in the same three different ways, and telling in each case practically the same tale. Last year similar sheep were kept on grass with the same allowance of cake and corn, hay ad. lib. but *no* turnips, and gained nothing, in fact, lost weight slightly. In the two previous years' sheep-feeding experiments, the gain on turnips was more per head, but the sheep were larger and the weather better. The experiments lead us to the following conclusions:—

1. Over and above manurial values, it pays well to cake and corn sheep on turnips with hay.
2. They pay better when penned on the turnip land, in spite of a muddy lair, than when receiving their turnips on grass land.
3. It does not pay to winter hoggs on pasture land with cake, corn, and hay without turnips; they wander about too much in search of a green nibble.
4. The progress of sheep on turnips with hay alone as an extra, is too slow in a very wet time to pay.

POTATO-GROWING EXPERIMENTS AT ABBEY HOLME, CUMBERLAND.

(These experiments were carried out on behalf of the County Council by a member of the Technical Education Committee, and have been reported upon by him. The portion of each plot weighed, was only $\frac{1}{312}$ of an acre and the results have therefore been expressed in "pounds per plot." A crop of 100 lbs. per plot would work out at almost 14 tons per acre.)

In the spring of 1900, with a view to the cropping properties of some new varieties of potatoes, four second early and five late varieties were planted on a moderate sandy loam broken out of lea and manured at the rate of 12 tons of well rotted Farmyard manure per acre. The tubers were planted on 25th April, and with the exception of 12 yards in each plot the plots were sprayed on August 8th. The potatoes all grew well, but ripened somewhat prematurely, and the crop, with one exception, is only a moderate one. A glance down the Table on p. 177 shows that, with the exception of the Duchess of Buccleuch, no variety has any exceptional merit. General White, though a fair cropper, is a red coloured variety and not likely to come into general use; it also had a large proportion of seed sized tubers. Cecil Rhodes and General French are both good croppers and both like coming into general use. It will be seen that, in the list with tried varieties, these nine new potatoes come out second, fifth, sixth, and seventh equal, but as it is probable they will keep better than Up-to-Date, the first four are well worth a further trial.

Variety.	Marketable Tubers.	Seed Size.	Chats.	Diseased.	Total per Plot.	Remarks.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
SECOND EARLY.						
The Gordon	14¾	22¾	5¾	27¾	70¾	A fair crop, but worthless from disease.
Challenge	33½	20¼	3	5¼	61¾	Small, and badly diseased where not sprayed.
Duchess of Buccleuch	91¾	23½	2¼	14¾	132	A good cropper, but somewhat liable to disease.
General French ...	47¾	15¾	2	9¼	74¾	Good crop.
LATE VARIETIES.						
Lord Kitchener ...	41¼	14¾	3	13¼	72¼	A fair cropper.
British Queen ...	37¼	27¾	2½	15¾	83¼	A fair crop, but somewhat small in size and considerably diseased.
Duke of Fife	41¾	8¾	1	16¼	67½	Fair crop.
General White ...	37¼	33½	5	2¼	78	Good crop, but too small, and bad colour.
Cecil Rhodes	54	20¼	2¼	9¼	85½	Good crop.

Effects of Spraying.—

Five acres of potatoes were sprayed on August 8th, somewhat later than should have been the case, especially with the early varieties. No rain fell for five days after the Sulphate was applied, so that the experiment had a fair chance. Not so much difference was observed in the prolonged growth of haulm as in previous years, and the tubers ripened somewhat prematurely. The weight of Copper Sulphate applied per acre for early varieties was 10 lbs. and for late varieties 15 lbs. per acre, with sufficient Lime to neutralize the acid. The average increase in sound tubers on seventeen varieties is equal to 2 tons 8 cwt. per acre, which at 40s. a ton comes to £4 16s. per acre, deducting the cost of material and labour say 8s. leaving a net profit of £4 8s. per acre.

Variety.	Sprayed.		Unsprayed.		Gain or Loss (–)	Best Cropper.
	Sound.	Diseased.	Sound.	Diseased.		
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
EARLY VARIETIES.						
Myatt's Kidney … …	59	6¾	53	5¾	5¾	—
Sharpe's Victor … …	62¾	7½	54½	5½	8¼	—
SECOND EARLY VARIETIES.						
Puritan … … …	80	5¾	72¼	5½	8	4th
Abundance … … …	67½	12	52¾	7½	14¾	9th
The Gordon … … …	43	27¾	27¾	27¾	15½	—
Challenge … … …	56½	5¼	40¼	30½	16¼	—
Duchess of Buccleuch …	85½	14¾	46¼	37¼	39¼	2nd
General French … …	64¾	9¼	50	16¼	15	7th equal
LATE VARIETIES.						
Lord Kitchener … …	59	13¼	37¼	20¼	19½	—
Fellside Rival … …	61	1	66¼	6¼	– 5¼	10th
Up-to-Date … … …	80¾	9¼	80¾	7½	—	3rd
Bruce … … …	68¼	5¾	54½	3¾	13¾	7th equal
Lord Dufferin … …	101	8¾	81½	17¼	19½	1st
British Queen … …	67½	15¾	31	26¾	37¾	8th
Duke of Fife … … …	51¼	16¼	33½	24	18	—
General White … …	75¾	2¼	49¼	24½	26½	6th
Cecil Rhodes … … …	76	9¼	51¾	14¾	24½	5th

REPORT OF THE LECTURER IN AGRICULTURAL CHEMISTRY, FOR 1900.

(Mr. S. H. Collins, F.I.C., F.C.S.)

This report contains both the work done in connection with last season's experiments and some previous work that has either not been published or is here published again for purposes of comparison. The total number of Analyses reported on is 195.

Methods of Analysis.

Excepting in the following particulars, the methods of analysis call for no comment. In order to avoid "difference figures," two or more constituents and their sum were separately determined, wherever such treatment was possible. The actual figures quoted are the means of the figures that were obtained in analysis. This method provides the best possible check consistent with making the whole equal the sum of its parts. For example; the various forms of Nitrogen and the total Nitrogen in Dung are each determined, and probable relative accuracies allowed for each direct and indirect determination.*

In Soil Analysis "Soluble in Hydrochloric acid" means the portion extracted in 48 hours at 100° Cent. by strong acid. "Soluble in Citric Acid" see Dr. Dyer's paper in the *Journal of the Chemical Society*, 1894. The dimensions of the particles of soil in the physical analysis are the average of those obtained by direct microscopic measurement of the fractions separated by sieves and sedimentation.

All figures are calculated to the Total Soil (including "Stones") dried at 100° Cent.

As some samples of Basic Slag contain some very coarse particles of metallic-iron, those portions which refuse to pass a sieve of 20 meshes to the inch are assumed to be worthless, and are removed previous to analysis and allowed for. The diameter of these particles is about 1 millimetre and upwards.

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* This adjustment is in all cases infinitesimal.

Experimental Work.

Turnips.—

Ten samples of turnips were analysed for their feeding value in connection with the Sheep-feeding Experiments see p. .111.

Each sample consisted of slices from 25 turnips, analysis being made of the slices dried at 60° Cent. No higher temperature was employed on account of the sugars present. The small turnips weighed 2 to 3 lbs., and the larger ones 5 to 6 lbs. They had been stored early in December and had, at the time of the analysis, been nearly 2 months in the pit.

It will be seen on reference to Table XV. that:—

(1) The water is invariably greater in the large turnips. The small turnips average about 10 per cent. more dry food material than the large.

(2) The sugar is very variable and forms the most important difference in feeding value.

(3) Most of the Nitrogen is in the form of Albuminoids, and most of the Carbon in the form of Sugar. Hence the roots were all well matured.

(4) The other constituents are very uniform.

The emphasis which these figures laid upon the importance of the percentage of Sugar in the Root crop, gave rise to the following investigation.

In February, 1900, a start was made in an attempt to breed up swedes to a high percentage of Sugar.

One hundred swedes were selected from general good appearance bored horizontally with an auger (see p. 114), the borings sealed in test tubes and despatched to the Laboratory. On arrival the percentage of sugar was determined roughly, so as to be able to pick out the richest and obtain seed from them.

As only a rough classification was needed, the sugar was estimated colorimetrically. The method was calibrated against pure cane sugar and the error was found to be ± ¼ per cent. between 4 and 6 per cent. and about ± ½ per cent. outside those limits.

The results were as follows:—

	Max.	Min.	Mean.
1st lot of 25 XL All Swedes	7·8	4·5	6·27
2nd " " "	7·4	4·7	6·22
3rd " " "	8·0	4·9	6·19
1st lot of 25 Monarch Swedes	8·0	3·7	5·40
From Table XV. " " (added for comparison)	6·1	4·2	5·29

It will be seen that there is great individual variation in the percentage of Sugar, yet the different sets are strictly comparable.

The last line added for comparison gives the maximum and minimum of the average of 25 swedes each. The mean is of 150 swedes of the same variety, as in the line above, but treated differently both in the field and laboratory. These figures serve to confirm the former ones.

In order to test whether the method of sampling gave a true sample of the individual swede, the following roots were bored horizontally in two directions and vertically:—

	Yellow turnip.			Swede.	
	Large.	Small.		Large.	Small.
Short horizontal bore	4·73	4·02	...	6·32	6·76
Long " "	4·41	4·05	...	6·06	6·77
Vertical bore...	3·90	4·50	...	6·58	6·71

Considering the large variations to be measured, the errors of sampling are of no importance. Further, there is no constant deficiency or excess in the analysis of bores taken in any one direction and hence for sampling roots in bulk, this method may be employed. But, from the results of the analysis of individual roots, it appears that 25 roots is not an unnecessarily large number, even when those roots have been picked out by an experienced farmer as apparently uniform. In order to obtain the average composition of the different varieties of swedes grown on the farm, it was, from the above data, considered advisable to take 50 roots and remove horizontal bores for analysis. In order to test the accuracy of this conclusion, all varieties were done in duplicate.

The results are not yet complete and will be kept over till another year.

A contribution to the knowledge of the chemistry of the turnip crop is contained in a paper by Dr. Somerville and Mr. Greig Smith published in the *Journal of the Society of Chemical Industry*, 1897. As the chemical details are not available to readers of the Report a brief abstract is appended.

Experiments were made to find out what became of the plant food supplied to the turnip crop, and the average result of Experiments on four farms was that for every 100 pounds of Phosphoric Acid and Nitrogen supplied as Artificials only to the turnip crop, but 19 pounds and 90 pounds respectively were returned in the crop.

For every 100 pounds Phosphoric Acid and Nitrogen supplied as Artificials with 16 loads of Dung per acre, 7 and 4½ pounds respectively were returned by the crop.

In both cases the residue would be of an insoluble nature, excepting the Nitrogen from the Artificials. This would be in the root-fibres and would decompose readily.

Meadow Hay, Tree Field.

In connection with the Experiments on the Relationship of Manures to Mutton (see Report 1899) the composition of the Hay crop is shewn in Table XXI.

Whilst the hay so obtained cannot exactly represent the grass eaten by the sheep, and the method of weighing the crop is ill suited to subsequent calculation, yet some valuable information may be gained by continuing the analyses for a few years. Owing to pressure of more important work it has been impossible to complete the analysis for 1900, and hence only the results for 1899 are shewn in Table XXI.

Meadow Hay, Palace Leas.—

This hay is used in Sheep-feeding Experiments now proceeding, the results of which will not be published till next year. The composition is given in Table XXVIII.

Seeds Hay, Tower Hill, 1899.*—

Table XVIII. gives the composition. It will be seen that the samples contain much woody fibre and little albuminoids, and are of poor quality. Plots 6 and 13 are, however, superior to the best hay of Tree Field. On referring to the Botanical analysis (Report 1899, p. 110) a close relationship between clover and albuminoids will be perceived. If the plots are placed in the order of decreasing values, from these two data we have:—

Chemical order, ...	Plots	6	4	1	3	2
Botanical „	„	4	6	1	2	3

Dung.—

This season two samples of Dung have been analysed. The Dung from Miniature Farm No. 3 (see p. 150) was making from 23rd Jan. to 14th Feb., 1900, when it was sampled and analysed. It was in a very moist condition and much fresher than in the previous year; containing in fact much unaltered urine. The bulk was kept in a cement lined pit till 31st May, when a second sample was taken. The long straw had scarcely rotted, but the Dung liquor was thick and brown, showing that some decomposition had taken place.

The results from 1897 are shown in Table XXXII. The figures for 1897 are those obtained by Mr. Greig Smith. The figures for 1898 and 1899 are republished for comparison. Further particulars may be found in the Report for 1899.

The percentage of water has not altered this season from February to May, and is much greater than in the former season. The percentage of organic matter has fallen in both seasons, and there has been an actual loss of 22 and 20 per cent. of the total amount of original organic matter.

There has been a loss of total Nitrogen equal to 23 and 29 per cent. in the two seasons, but in the former season the loss has practically all fallen on the non-albuminoid Nitrogen, whereas in the present season about one-third of the total loss is from the albuminoids. This is doubtless due to the fact that the Dung was much fresher this season.

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* See Annual Report for 1899, page 40.

The Phosphoric Acid shows a gain in one season and a loss in the other. The Potash shows losses equal to 12 and 30 per cent. The Lime shows a gain in one season and a loss in the other.

The Insoluble Silicates show a gain in both seasons, whilst the Soluble Mineral Matter shows a loss of 12 per cent. in each case.

With the two exceptions therefore of Phosphoric Acid and Lime the results of the two seasons are in strict accordance, and these two exceptions, being in smaller quantities, are liable to greater proportionate errors than the other constituents.

The losses of Soluble Mineral Matter and Potash are, however, too large and consistent to be passed over and can only have occurred by drainage.

If all the water and soluble matter of the Dung could have been placed by itself in the pit it would have stood about 40 inches deep. A loss of 20 per cent. would mean that 8 inches of Dung liquor had drained away in 106 days or $\frac{1}{16}$ inch per diem.

Moreover in the pit the Dung liquor is not homogeneous. Rain falls on the surface and washes the soluble matter downwards, so that the liquor at the bottom of the pit is a stronger solution than the average, and hence a still smaller leakage than $\frac{1}{16}$ inch per diem would suffice to account for the losses shewn.

A similar calculation for the season 1898-1899 shews that a leakage of $\frac{1}{8}$ inch per diem would account for 20 per cent. loss.

The gain in Silicates is easily accounted for. Earth is used to weight the heap and it is impossible to avoid getting earth mixed up with the Dung.

The insoluble Silicates bring with them also some matter soluble in Hydrochloric Acid since earth always contains both. Hence the real loss of soluble mineral matter is greater than that shown, especially in the present season. Since no explanation except drainage can account for the loss of the mineral matter, drainage may also explain the loss of Nitrogen. Nitrogen may be given out to the air either as elementary Nitrogen or Ammonia, or it may be lost as drainage. In Laboratory experiments on the Dung of both seasons, I have found only the most trifling losses when the manure was kept under either aerobic or anaerobic conditions, but rendering drainage impossible.

The above facts give no support to the theory that Nitrogen is lost by fermentation. They prove conclusively that much matter is lost by drainage, even in such cement-lined pits as it seems practicable to construct on the farm.

Soils.—

Table XXIX. contains the composition of all the soils of Cockle Park Farm that have been analysed.* The soil is very variable, and hence different fields have very different composition. In order to render this matter comprehensible in tabular form, the physical composition of the soils analysed during this year has been added. These soils are under various experiments and it is as yet premature to discuss them in detail, but the analyses are published for general information.

Tree Field is a clay soil very poor in Phosphoric Acid. Hence the enormous importance of manures containing that constituent. Potash, Lime, and Nitrogen are present in moderate amount, but, relatively to the Phosphoric Acid, are abundant, hence as manures they produce little effect, except when in conjunction with Phosphates.

Long Riggs is also a soil deficient in Phosphoric Acid and much benefited by Basic Slag.

The weight per cubic foot of Tree Field soil is given in Table XXX.

Table XXXI. gives the composition of soils in the counties of Cumberland, Durham, and Northumberland exclusive of Cockle Park Farm.

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* The soils of the Miniature Farms were analysed by Mr. Greig Smith, M.Sc.

COMMERCIAL PRODUCTS.

As a rule these have been of a high quality.

The following only require comment:—Linseed Cake No. 233, contained some starch and Polygonum and was not equal to the quality obtained in former years.

No. 235 was a decorticated Cotton Cake Meal of good quality.

Superphosphate No. 241 was a cheap and fine sample. Dissolved Bone, No. 242, was superior to any received here before.

Precipitated Phosphate, No. 248, was a mixture of di- and tri-basic Phosphate of Lime.

APPENDIX.

TABLE I.—EXPERIMENT ON SWE

Plots.	Manuring per Acre.								Cost of Artificials.			Earl's House.	
	Dung.	Sul. of Am.	Nitrate of Soda.	Super.	Slag.	Bone Meal.	Fish Meal.	Kainit.					
	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	£	s.	d.	T.	cwt.
1	18	...	...	...	...	...	...	...	4	10	0	20	10¾
2	18	42	56	392	...	...	...	200	5	14	0	21	5
3	12	42	56	392	...	...	...	200	4	4	0	22	3¼
4	12	42	56	...	284	...	...	200	3	19	0	22	0
5	12	21	28	...	...	210	...	200	4	0	0	20	12½
6	12	...	...	314	...	...	214	200	4	6	6	18	10
7	12	32	42	196	...	105	...	200	4	2	0	16	12¼
8	12	42	56	392	...	...	...	...	3	19	6	18	2½
9	12	...	...	392	...	...	...	200	3	15	0	20	5
10	12	...	...	...	...	...	...	...	3	0	0	19	4¼
11	...	...	...	...	...	...	...	...	......			9	8¼
12	...	42	56	392	...	...	...	200	1	4	0	17	5
13	...	84	112	784	...	...	...	400	2	8	0	19	7¼
14	...	84	112	...	568	...	...	400	1	18	0	19	0
15	...	44	58	...	...	420	...	400	2	0	0	16	13½
16	...	...	...	628	...	...	428	400	2	13	0	19	12½
17	...	64	84	392	...	210	...	400	2	4	0	16	17½
18	...	...	110	784	...	...	...	...	1	19	0	13	15
19	...	...	...	784	...	...	...	400	1	10	0	17	17¼
20	...	...	56	...	...	...	...	200	1	7	0	16	10

URHAM. PLOTS $\frac{1}{27}$ ACRE; $\frac{1}{40}$ ACRE WEIGHED.

Little hilton.	Offerton Hall.	Seaham Harbour.	Skerningham.*	South Hetton.	Summerhouse.	West Cornforth.*	Average.	Plots.
T. cwt.	T. cwt.	T. cwt.	T. cwt.	T. cwt.	T. cwt.	T. cwt.	T. cwt.	
22 2½	23 4	10 6	11 17¾	16 8¼	20 15	8 14¾	19 8¾	1
19 16½	24 7¼	13 0	14 18½	18 5	21 0¾	13 15¼	20 5	2
18 10¾	19 14¾	16 2½	15 11¼	16 2¾	22 10	13 9¾	20 4¼	3
18 6	18 12¾	15 11¼	12 18¼	18 10¾	22 15	14 14¾	20 0	4
17 15¾	16 5¼	13 10¾	12 8¼	22 7¾	21 15	14 9	19 5	5
6 15	16 16¾	14 12½	16 6¾	20 14¼	22 8¼	15 19¼	19 6	6
17 5¾	18 17¼	18 1	13 16½	22 5¾	22 3½	13 17½	20 3¼	7
17 12¼	18 10¾	19 7½	9 18½	16 15	20 0	10 1¾	19 6¾	8
6 15	20 10¾	15 12¼	8 14¼	14 5	19 1	7 17½	18 3¾	9
6 10¾	19 3¼	13 0	12 11	14 16½	18 6	11 13½	17 12¼	10
7 6½	14 14¾	1 2½	1 10¾	0 0¾	5 4¼	8 1¾	6 0	11
8 17½	21 6½	10 10¼	8 0¾	13 7¼	16 2½	11 16¾	15 4¼	12
3 5	20 16	16 0	13 6¾	16 15	19 7½	16 11	18 2	13
2 7½	16 14¼	14 11	11 13½	16 17¾	20 1¾	15 15¾	17 10	14
1 16½	14 16¾	10 17¼	10 4¼	16 0	18 11	10 5¼	15 16¾	15
5 0	17 18¼	14 2¾	11 17½	12 13¼	21 17½	9 7¾	17 14¾	16
4 8¼	18 14	16 11½	10 12½	9 2¾	21 6¾	9 2¼	17 1	17
9 10	18 12¾	17 5	11 9¼	12 5	15 19¼	11 17½	15 13¼	18
8 12½	21 6½	8 0¾	12 11½	10 2¾	15 3½	9 12¾	14 6¾	19
0 13½	16 1¾	1 17½	6 12½	0 1	6 0	14 16¾	7 10¼	20

* Excluded from average.

TABLE II.—EXPERI

Plots.	Manures applied per Acre.								Cost of Manures.		Thornley.			Old Tri	
	Dung.	Sulph. Amm.	Nit. of Soda.	Super.	Kainit.	Muriate of Potash.	Sulp. of Potash.	Fish Meal.			Large.		Small.	Large.	
	T.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	s.	d.	T.	cwt.	Cwt.	T.	cwt.
1	12	...	...	...	...	...	...	...	60	0	7	13½	12¾	8	17½
2	12	126	...	196	...	...	79	...	83	0	8	19¼	14¼	9	4¾
3	12	252	...	392	...	...	158	...	106	0	9	19¼	14¼	9	0¼
4	...	252	...	392	...	...	158	...	46	0	8	15	10¾	8	5¾
5	...	126	168	392	...	...	158	...	46	0	7	4¼	16½	9	1
6	...	126	...	276	...	...	158	321	48	0	7	10	14¼	9	1¾
7	...	252	...	392	...	...	316	...	54	6	7	12¾	14¼	9	11¾
8	...	252	...	392	...	168	...	...	51	6	8	6½	10	9	10
9	...	252	...	392	808	...	...	...	54	0	7	14¼	11½	7	15¼
10	...	...	...	...	...	...	...	...	...		6	0¾	15¾	6	5

S. COUNTY DURHAM.

n.	Seaham Harbour.				Stanley.			Hedley West House.*			Average Yield per Acre of Five Stations.			Average per cent. Small.
Small.	Large		Small.	Diseased.	Large.		Small.	Large.		Small.	Large.		Small	
Cwt.	T.	cwt.	Cwt.	Cwt.	T.	cwt.	Cwt.	T.	cwt.	Cwt.	T.	cwt.	Cwt.	
10¼	6	8¼	19¼	¼	7	4	11¾	7	7½	6½	6	17¼	15	9·8
10¼	8	2¼	21	¼	8	4	11	6	9	9¼	8	2	14½	8·2
13¼	8	17¾	19¾	¼	7	7¼	11½	6	16¾	10	8	6¼	13¾	7·6
8¾	7	13¼	16¾	½	5	10¾	10¾	2	11	5	7	2½	11¼	7·3
10¾	7	16	15¼	¾	6	12¾	15	6	11½	7½	7	8¾	14¾	8·0
11¾	7	16¾	14¾	¾	7	13¼	10	5	1¾	6¾	7	12¾	13¾	8·2
7½	7	11¾	15	¾	8	16½	12½	5	13¼	4¼	7	19	14¾	8·5
5¼	7	12¾	14¼	¾	7	4¾	11¾	6	9¼	4	7	13¼	13½	8·1
20¼	7	11½	11	½	6	6½	8¼	2	9¾	5	6	12½	13	8·9
12½	4	6	10¾	...	3	9	6¾	2	4¾	11½	4	9	11¾	11·7

* Excluded from average.

TABLE III.—PERCENTAGE OF DRY MATTER IN POTATOES GROWN WITH DIFFERENT MANURES.

Centre.	Plot.						
	1	3	4	7	8	9	10
	12 Tons Dung.	12 Tons Dung with Artificials of Plot 4.	7¼ cwt. of Artificial Manure.*	Same as Plot 4 but 100 lbs. Potash in Sulphate.	Same as Plot 4 but 100 lbs. Potash in Muriate.	Same as Plot 4 but 100 lbs Potash in Kainit.	No Manure.
Trimdon	23·87	23·02	23·75	25·75	24·22	22·43	23·32
Seaham Harbour	23·62	23·48	23·23	22·30	22·64	21·10	24·95
Swalwell	15·21	20·33	20·90	19·32	21·24	19·67	21·13
Stanley	21·78	22·28	24·19	24·44	22·35	18·80	23·63
Thornley	22·13	22·15	23·33	22·80	21·20	19·77	23·90
Old Trimdon	20·67	19·38	21·36	21·50	21·20	21·01	22·71
Averages excluding Swalwell. .	22·41	22·06	23·17	23·36	22·32	20·62	23·70

* The Mixture for Plot 4 consisted of 2¼ cwt. Sulphate of Ammonia (52½ lbs. Nitrogen), 3½ cwt. Superphosphate (56 lbs. Phos. Acid) and 1½ cwt. Sulphate of Potash (50 lbs. Potash) per acre.

TABLE IV.—EXPERIMENT ON SEEDS HAY IN COUNTY DURHAM.

Per Acre.

Plots.	Artificial Manures.				Cost of Artificials.	Offerton Hall.		Thorpe Thewles		Binchester Crag.	Shield Row.	Witton Gilbert.	Old Durham.	Stanley.*	Whitehurworth.*	Lanchester.*	Kelloe.*	Average of Six Stations.	Profit Hay at 60s. per ton.	Plots.
	Sulp. of Ammonia.	Nitrate of Soda.	Super.	Kainit.		1st Crop.	2nd Crop.*	1st Crop.	2nd Crop.*											
	lbs.	lbs.	lbs.	lbs.	s.	cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt	s. d.	
1A	—	—	—	—	—	34¾	26½	32¼	16	26	17	29¾	38	27¼	66¼	13½	26¼	29½	—	1A
2,,	168	—	—	—	18	49	24½	33¾	16	37½	31¼	31¾	46¼	35¾	59¼	17¾	25	38¼	8 3	2,,
3,,	—	224	—	—	18	50½	26¾	41½	16½	36	32½	40¾	44¼	26¼	65¾	23¾	22	41½	18 0	3,,
4,,	84	112	—	—	18	53¼	24¼	40¾	17½	37¼	27¾	50	49¼	26¾	59¾	20½	22½	43	22 6	4,,
5,,	42	56	—	—	9	43¼	27¾	28¼	17	30¼	26½	43¾	43	21¼	57½	19¾	20¾	35¾	9 9	5,,
1B	—	—	—	448	9	33¾	22¾	31	17	26½	14¼	29¾	43½	14¾	61¼	8½	22½	29¾	8 3	1B
2,,	168	—	—	448	27	50	18¼	41¼	15¼	34	31¾	36	43¼	20¼	59	19½	26¾	39½	3 0	2,,
3,,	—	224	—	448	27	53	20¾	42¼	14	36	35	43½	46	26	58¾	20½	28	42¾	12 9	3,,
4,,	84	112	—	448	27	52¼	17¾	43½	15	37¼	30¼	43¾	45½	25	68¾	20	24½	42	10 6	4,,
5..	42	56	—	448	18	44¼	21¼	34¾	16¾	32½	22¾	42¼	43¼	20¼	58¼	16¾	25¾	36¾	3 9	5,,
1C	—		448	448	19	39¾	30¾	36¼	17¾	30¾	14	31¼	41¼	17¼	60	12¾	26	32¼	10 9	1C
2,,	168	—	418	448	37	56¾	21¾	41¼	17	38½	32¼	38¾	46¼	22½	56	25¼	29¾	42¼	1 3	2,,
3,,	—	224	448	448	37	56¼	26	42½	16	41¾	28½	47	45	24½	56¾	21¼	32¼	43½	5 0	3,,
4,,	84	112	448	448	37	57	25	42¾	14¼	42	28¾	47¾	43¼	19	61	22	27	43½	5 0	4,,
5,,	42	56	448	418	28	52½	25	38¾	17	35¼	20¼	38¼	45	19½	59¼	18¾	25¼	38¼	1 3	5,,

* Excluded from the average.

TABLE V.—COMPLETE RESULTS OF A FIVE-COURSE ROTATIO

Plots.	MANURING PER ACRE FOR POTATOES.								POTATOES, 1896.				BARLEY, 1897.			
	Dung	ARTIFICIALS.							Yield per Acre of Large Potatoes.		Value at 50s. per Ton.		Yield per Acre of Grain.	Yield per Acre of Straw.	Value a 30s. per and St at per To	
		Sulphate of Ammonia.	Nitrate of Soda.	Super.	Slag.	Dissolved Bones.	Bone Meal.	Kainit.								
	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	T.	cwt.	£	s.	Bushel of 56 lbs.	Cwt.	£	s
1	12	...	252	840	...	...	...	840	11	1¼	27	13	37¼	30	8	18
2	12	...	252	560	...	...	...	560	10	16	27	0	36½	26¾	8	10
3	12	...	168	840	...	...	...	560	11	0¾	27	12	36½	26½	8	10
4	12	...	168	560	...	...	...	840	11	8¾	28	12	32½	24¾	7	13
5	12	...	168	560	...	...	...	560	10	12¾	26	12	31¼	24	7	7
6*	12	126	...	560	...	...	..	560	10	17	27	3	33½	24¾	7	17
7	12	126	...	560	...	...	...	...	11	4	28	0	33½	23¾	7	16
8	12	126	...	...	...	...	...	560	10	4¾	25	12	32¾	24¼	7	13
9	12	...	...	560	...	...	...	560	8	19¼	22	8	30¾	23	7	5
10	...	...	...	...	...	...	...	...	4	12¾	11	12	22	18	5	5
11	12	126	...	...	672	...	...	560	10	1½	25	4	35	25½	8	4
12	12	56	...	...	...	462	...	560	9	5½	23	4	29	23¾	6	19
13	12	37	...	...	...	...	504	560	8	13½	21	14	28¼	22¾	6	14
14	12	94	34	224	134	92	101	560	9	19½	24	19	26¼	23¾	6	7
15†	12	...	...	...	...	...	...	...	9	6¼	23	6	27¼	23½	6	11
16‡	12	188	67	448	269	185	202	560	10	5½	25	14	35¼	26¼	8	5
17§	12	94	34	224	134	92	101	560	10	7	25	18	31	23½	7	5
18‖	12	47	17	112	67	47	50	280	9	10	23	15	25¼	19½	5	19
19	12	...	...	...	...	...	...	...	9	12¼	24	1	28	21½	6	12
20¶	...	94	34	224	134	192	101	560	6	18¾	17	7	21¼	19¼	5	
21	18	...	...	...	...	...	...	...	11	4½	28	1	34¼	25¾	8	1
22	24	...	...	...	...	...	...	...	11	10½	28	16	40¾	31	9	12

MANURING FOR SUBSEQUENT CROPS, viz., Barley, 1897; Hay, 1898; Hay, 1899; Oats, 1900.

* Plot 6, 126 lbs. of Sulphate of Ammonia to Hay in 1898 and 1899, and to Oats in 1900.

† Plot 15, for Barley, ½ of Artificial Dressing of No. 14 (but no Nitrate of Soda or Sulphate of Ammonia). For each of the other Crops as for the Barley but with 9⅓ lbs. of Nitrate of Soda, and 28lbs. Sulphate of Ammonia.

‡ Plot 16, 140 lbs. Kainit for each crop.

§ Plot 17, same as Plot 15.

‖ Plot 18, half-dressing of Plot 5.

¶ Plot 20, same as Plot 18.

MENT AT KIMBLESWORTH (DURHAM). EACH PLOT = ⅛ ACRE.

, 1898	HAY, 1899.		OATS, 1900.			Total Value in in Five Years.	Cost of Manures.	Plots.
Value at £3 per Ton.	Yield per Acre.	Value at 50s. per Ton.	Yield per Acre of Grain.	Yield per Acre of Straw.	Value of Grain at 21s. per Quarter, and Straw at 35s. per Ton.			
£ s.	Cwt.	£ s.	Bushel of 42 lbs.	Cwt.	£ s.	£ s.	£ s. d.	
5 15	24	3 0	56	26¾	9 14	55 0	5 16 4	1
5 7	22¼	2 16	55½	22	9 4	52 17	5 3 9	2
5 17	22¼	2 16	54½	20¾	8 19	53 14	5 4 2	3
5 12	25½	3 4	52½	20¾	8 14	53 15	5 3 8	4
5 13	26¼	3 6	52¾	25½	9 3	52 1	4 17 7	5
6 4	31¾	3 19	59¾	22½	9 17	55 0	6 15 8	6
4 18	23¾	2 19	52	21¼	8 14	52 7	4 3 0	7
5 2	24	3 0	49¾	21¼	8 8	49 15	4 2 0	8
5 2	23¼	2 18	48¼	20½	8 3	45 16	4 5 2	9
4 18	20¾	2 12	44½	18¼	7 9	31 16	... ...	10
5 16	23½	2 19	46¼	18¼	7 13	49 16	4 16 3	11
5 11	22¾	2 17	43	17½	7 4	45 15	4 18 2	12
5 12	21½	2 14	43½	20	7 9	44 3	4 18 8	13
5 8	21¼	2 13	45	19	7 11	46 18	4 17 1	14
5 19	23½	2 19	50¼	21¾	8 10	47 5	4 17 1	15
5 18	23½	2 19	51½	21¾	8 13	51 9	6 14 2	16
6 7	23¾	2 19	49½	24	8 12	51 1	6 14 2	17
5 19	21	2 13	45¼	19	7 12	45 18	4 17 1	18
5 10	23½	2 19	44½	17¾	7 7	46 9	3 0 0	19
5 17	22	2 15	44	21¼	7 13	38 16	3 14 2	20
5 14	22	2 15	48¼	24¼	8 9	53 0	4 10 0	21
5 10	25¼	3 3	54¾	25¾	9 9	56 10	6 0 0	22

TES.—The artificial mixtures used on Plots 5, 11, 12, 13, 14, 17 and 18, supplied 26½ lbs. Nitrogen, 73 lbs. Phosphoric Acid, and 72 lbs. Potash per Acre In the case of Plots 13, 14, 16, 17, 18 and 20. the weights of Artificial Manures applied are given to the nearest whole number.

TABLE VI.—ROTATION EXPERIM

EACH PLOT = ¼ ACR

Plots.	Manuring per Acre for						Swedes, 1896.		Oats, 1897.		
	Swedes, 1896.		Cereal, 1897.	Hay, 1898.	Hay, 1899.	Cereal, 1900.	Yield per Acre.	Value at 8s. per Ton.	Yield of Grain per Acre.	Yield of Straw per Acre.	
	Dung.	*Mixed Artificials.	Mixed Artificials.	Mixed Artificials.	Mixed Artificials.	Mixed Artificials.					
	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	T. cwt.	£ s.	Bush. of 42 lbs.	Cwt.	£
1	...	784	...	...	...	...	Swede Crop Failed.	...	34	27¾	6
†2	...	784	...	...	...	...		...	37½	31	7
†3	...	560	56	56	56	56		...	35¾	29½	7
4	6	...	...	...	...	...		...	31½	23	5
5	6	784	...	...	...	...		...	38½	32	7
6	6	157	157	157	157	157		...	37¾	28¼	7
†7	6	157	157	157	157	157		...	34	24¼	6
8	9	...	...	...	...	...		...	37½	27	7
9	9	784	...	...	...	...		...	43½	30¼	8
10	9	157	157	157	157	157		...	41½	32½	8
11	...	...	...	...	...	...		...	32¼	22¾	6
12	12	...	...	...	...	...		...	38¾	29¾	7
13	12	784	...	...	...	...		...	49	37¾	9
14	12	157	157	157	157	157		...	44½	29	8
15	15	...	...	...	...	...		...	38½	27¾	7
16	15	784	...	...	...	...	26 1	10 8	39	28¼	7
17	15	157	157	157	157	157	19 18	7 19	38¾	28	7
†18	12	157	157	157	157	157	21 1	8 8	37	30½	7
19	12	1568	...	...	...	...	24 13	9 17	39	25	7
20	12	784	196	196	196	196	24 12	9 17	44½	30¾	8
21	12	314	314	314	314	314	24 7½	9 15	45	28	8
22	12	...	196	196	196	196	23 3	9 5	42½	27¼	7
23	12	392	...	131	131	131	24 10½	9 16	40¼	27½	7
24	12	...	...	261	261	261	21 11	8 12	36¾	25	6

* The "Mixed Artificials" consisted of 224lbs. Bone Meal, 224 lbs. Diss. Bones, 168 lbs. Su
112 lbs. Fish Meal, and 56 lbs. Sulphate of Ammonia.

ROSE BANK, DALSTON, CUMBERLAND.

ANTITIES STATED “PER ACRE.”

Hay, 1898.	Hay, 1899.		Oats, 1900.					
Value at £3 per Ton.	Yield per Acre.	Value at 50s. per Ton.	Yield of Grain.	Yield of Straw.	Value Grain at 20s. per Qr. and Straw at 35s. per Ton.	Total Value of the four Crops.	Total Value of the five Crops.	Plots.
£ s.	Cwt.	£ s.	Bush. of 42 lbs.	Cwt.	£ s.	£ s.	£ s.	
5 8	28½	3 11	57¾	27	9 11	25 4	...	1
5 14	31	3 18	68¾	30½	11 5	28 5	...	2†
5 14	29¾	3 14	59	28¼	9 17	26 6	...	3†
4 7	23¼	2 18	49¾	22½	8 3	21 7	...	4
5 10	32	4 0	62¾	30¾	10 11	27 13	...	5
5 8	35	4 8	58	32¼	10 1	27 1	...	6
5 1	29¼	3 13	51¼	21½	8 6	23 7	...	7†
4 7	24½	3 1	57¾	28	9 13	24 2	...	8
5 9	34½	4 6	64¾	32¼	10 18	28 15	...	9
4 13	32¼	4 1	63	29¾	10 10	27 5	...	10
3 15	21¾	2 14	57	18½	8 15	21 5	...	11
4 15	30½	3 16	56¾	21½	9 0	25 0	...	12
5 13	33¼	4 3	56¼	35	10 2	29 7	...	13
5 7	31	3 18	59	32½	10 5	27 12	...	14
5 8	28½	3 11	53¼	25¾	8 18	25 2	...	15
5 16	30¼	3 16	65	27¾	10 12	27 11	37 19	16
5 19	33¼	4 3	61¾	31	10 8	27 16	35 15	17
5 19	32¼	4 1	61¾	28½	10 4	27 10	35 18	18†
5 7	27½	3 9	60¼	28¾	10 1	25 18	35 15	19
5 14	31	3 18	69¾	32¾	11 11	29 8	39 5	20
5 14	28	3 10	64¾	28½	10 12	27 18	37 13	21
5 11	30¼	3 16	67¼	28½	10 18	27 19	37 4	22
5 18	29¼	3 13	61¾	31¾	10 10	27 10	37 6	23
6 11	26¼	3 6	59	28½	9 18	26 11	35 3	24

† In addition to the above “Mixed Artificials” these Plots received Kainit, viz.:—Plot 2, 448 lbs.
the Swedes; Plots 3, 7 and 18, 224 lbs. to Swedes, and 112 lbs. to each of the Hay Crops.

TABLE VII.—SEVENTH YEAR OF A ROT
PLOTS ¼ ACRE, EXCEPT PLOTS 10 AND 10A

Plots.	Manuring per Acre for Swedes in 1898.							Swedes, 1898.				
	Dung.	Super.	Slag.	Dis. Bones.	Bone Meal.	Fish Meal.	Kainit.	Yield at Peepy.		Yield at Whitefield.		A Yi
	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	T.	cwt.	T.	cwt.	T.
1	12	...	...	...	...	...	...	15	12	21	2	18
2	12	616	...	...	...	224	...	16	13	21	18	19
3	12	1,232	...	...	...	448	...	17	6	23	3	20
*4	12	308	...	...	...	...	...	17	8	22	14	20
*5	6	616	...	...	...	224	...	16	8	22	8	19
6	6	616	...	...	...	224	...	16	6	23	2	19
7	9	616	...	...	...	224	...	16	10	22	17	19
8	15	616	...	...	...	224	...	17	3	24	2	20
9	12	308	...	...	...	112	...	17	0	24	3	20
10	...	...	...	...	...	...	...	10	6	12	10	11
10A	12	...	...	...	...	...	...	17	4	23	4	20
11	12	...	...	...	420	...	...	17	8	21	17	19
12	12	...	...	560	...	...	...	17	5	22	2	19
13	12	616	...	...	...	224	...	17	2	22	16	19
14	12	...	476	...	...	224	...	16	16	22	8	19
15	12	616	...	...	...	224	448	17	13	22	18	20
*16	12	308	...	...	...	112	...	16	0	22	6	19
*17	12	616	...	...	...	224	...	16	17	21	3	19
*18	12	308	...	...	...	...	...	15	18	22	0	18
*19	†12	308	...	...	...	...	...	16	2	23	8	19
*20	‡24	308	...	...	...	...	...	15	1	21	4	18

All plots received ½ cwt. Nitrate of Soda for the Hay, and those marked * received the
indicated in addition.

BARLEY, 1899.—Plot 4. 224 lbs. Fish Meal. Plot 16, 56 lbs. Fish Meal.

HAY, 1901.—Plot 4, 308 lbs Super.; Plot 5, 6 tons Dung; Plot 16, 154 Super., 224 lbs. Kai
17, 448 lbs. Kainit; Plots 18, 19, and 20, 308 lbs. Super., 112 lbs. Fish Meal, and 112 lbs.
each.

'ERIMENT AT PEEPY AND WHITEFIELD, NORTHUMBERLAND.

⅛ ACRE. QUANTITIES STATED PER ACRE.

Barley 1899.					Hay, 1900.				Average Yield 1st and 2nd Crops	Plots.
at Peepy.	Yield at Whitefield.		Average Yield.		Yield at Peepy.		Yield at Whitefield.			
Straw.	Grain.	Straw.	Grain.	Straw.	1st Crop	2nd Crop	1st Crop	2nd Crop		
Cwt.	Bush. of 56 lbs.	Cwt.	Bush. of 56 lbs.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.		
29¼	40	20¾	41¼	25	43¼	15	35	1¾	47½	1
30	42¼	23¼	43¼	26½	46	16	36¾	4½	51¾	2
30¾	48½	24¾	47½	27¾	47	17¼	38¼	5	53¾	3
32¼	51¼	27½	51	29¾	46½	17	43	4¾	55¾	4*
27½	43¾	22¾	42¾	25	42½	19¾	49½	9¾	60¾	5*
24½	45	24½	44¼	24½	43¾	13	36¾	3¼	48½	6
28½	47¼	27½	46¼	28	40¾	14¾	41¼	3½	50¼	7
31¼	49½	30¼	48¾	30¾	48½	18½	44¾	6½	59¼	8
26½	51¾	28½	49	27½	35½	15¾	40¾	4½	48¼	9
20¼	30¼	19½	29¾	19¾	39½	10½	29	1½	40¼	10
25	45¾	25¼	43½	25	44¾	14	44¼	5¾	54½	10A
28	46¾	24½	47	26¼	43¾	13¼	41½	5	51¾	11
28	45¼	23	46	25½	39	14	44	5¼	51¼	12
24½	45½	24	46¾	24¼	43¼	13	44½	7½	54¼	13
30¾	46¼	23¾	48½	27¼	43¼	15	44	3¾	53	14
29¾	47¼	24¼	48	27	43¾	14¾	43¼	4	53	15
28	52	24¼	50	26	44¾	14	46½	5¼	55¼	16*
28¼	49¾	25	49½	26½	44¼	12¼	43½	4½	52¼	17*
28¼	47½	24¼	48	26¼	44¼	11½	44½	3¾	52	18*
29	51	24¾	50	26¾	44¾	11¼	45½	2½	52	19*
31¼	47¼	24	47	27½	41¾	8¾	39½	2¾	46½	20*

ATS. 1901. —Plot 16, 154 lbs. Super., 56 lbs. Fish Meal, and 224 lbs. Kainit; Plot 18, 112 lbs. Fish Meal.

12 tons Horse Dung, well rotted, at Whitefield; 15 tons, fresher, at Peepy.

24 tons Newcastle Corporation Manure at both stations.

TABLE VIII.—ROTATION EXPERIMENT AT THE

EACH PLOT = 1/16 ACRE, SURROUNDED BY A 3

Plots.	Manuring of Potatoes, 1897.	Manuring of Turnips, 1899.	Yield of Potatoes, 1897.		Va Larg per and at
			Large.	Small.	
			T. cwt.	T. cwt.	£
1	Unmanured throughout... ...	... ...	8 17¾	1 2¼	27
2	12 tons Dung	... ...	13 1¾	2 2½	41
3	6 tons Dung	6 tons Dung ...	11 5	1 12¾	35
4	12 tons Dung + { 25 lbs. Nitrogen 100 lbs Phos. Acid 35 lbs. Potash	... ...	12 7¾	2 1¼	39
5	12 tons Dung	{ 25 lbs. Nitrogen 100 lbs. Phos. Acid 35 lbs. Potash }	10 4¾	1 14½	32
6	12 tons Dung + { 12½ lbs. Nitrogen 50 lbs Phos. Acid 17½ lbs Potash	Artificials of 1897 repeated	9 13¼	1 16¾	30
*7	12 tons Dung + { 8⅓ lbs. Nitrogen 25 lbs. Phos. Acid 8¾ lbs. Potash	{Artificials of 1897 repeated}	9 0½	2 4¼	29
8	12 tons Dung + { 50 lbs. Nitrogen 200 lbs. Phos. Acid 70 lbs. Potash	... ...	11 5¾	1 18¾	35
9	As on No. 8, but no Dung ...	... ...	9 6¾	2 3½	30

* Manuring of Beans, 1898,—25 lbs. Phos. Acid, 8¾ lbs. Potash.
Manuring of Vetches, 1900,—Artificials of 1899 repeated.

COUNTY SCHOOL, BARNARD CASTLE, CO. DURHAM.

BORDER. QUANTITIES STATED PER ACRE.

Yield of Beans, 1898.		Value of Beans at 30s. per qr.		Yield of Turnips, 1899.		Value at 6s. 8d. per ton.		Yield of Vetch Hay.	Value at £3 per ton.		Total in four years.		Increase over unmanured.		Plots.
Bushels of 63 lbs.	Straw.														
	Cwt.	£	s.	T.	cwt.	£	s.	Cwt.	£	s.	£	s.	£	s.	
12¾	11¼	2	8	2	17½	0	19	17	2	11	33	13	—		1
29½	22½	5	11	7	0¾	2	7	25¾	3	17	53	3	19	10	2
25¾	20¼	4	17	7	3	2	8	24¼	3	13	46	6	12	13	3
24	19	4	10	14	3¾	4	15	31¼	4	14	53	3	19	10	4
30½	21½	5	14	18	2¾	6	1	80¼	4	11	48	15	15	2	5
38¼	27	7	3	15	7	5	2	25½	3	17	46	19	13	6	6
33¾	19	6	7	13	6¼	4	9	33½	5	1	45	3	11	10	7
37	24¾	6	19	12	13½	4	4	28½	4	6	51	5	17	12	8
11½	12¾	2	3	13	5½	4	9	26½	4	0	40	16	7	3	9

TABLE IX.—SIXTH CROP OF CUMBERLAND

Plots.	Manuring per Acre for Crop, 1896, 1897, 1898, 1899, and 1900, and almost the same for 1895.							Produce of Hay per Acre, 1900.			
	Dung.	Sulph. of Amm.	Nitrate of Soda.	Super.	Slag.	Kainit.	Cost of Artificials per Acre for 1900.	Blencow.	Castle-Carrock.	Eskdale.	Glasson.
	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	s. d.	Cwt.	Cwt.	Cwt.	Cwt.
1	...	...	...	...	...	...	...	32¾	21	22¾	8
2	...	...	112	...	...	...	9 0	34	22½	27¼	7¾
3	...	...	...	280	...	...	7 8	39¼	29¾	31	11
4	...	...	...	...	208	...	4 0	32½	24¾	23¼	13
5	...	...	...	...	...	280	5 8	35¼	36¾	26¾	19
6	...	...	112	280	...	...	16 8	36	24	31½	21
7	...	...	112	...	...	280	14 8	38¼	40¼	37½	18¼
8	...	...	...	280	...	280	13 4	33	35¼	45½	19¼
9	...	...	112	280	...	280	22 0	37½	48	42¾	17¾
10	...	...	112	...	208	280	18 4	38¼	36¾	40¾	17¼
11	...	...	112	140	104	280	20 6	38	47	35¾	17
12	...	86	...	...	208	280	18 8	37¼	32¼	33¾	20¼
13	10	43	...	...	104	140	9 4	33¼	44¾	30¾	10¼
14	...	43	...	...	104	140	9 4	34¼	28¼	37½	10¼
15	10	43	...	...	104	140	9 4	38	32½	39¾	12
16	10	...	...	...	...	...	...	35½	24¾	44½	16¼

The mixtures for Plots 9—12 supply 17·5 lbs. Nitrogen, 35 lbs. Phos. Acid, and 35 lbs. Potash per Acre.

Plot 13 gets Dung and Artificials separately in alternate years, namely, Dung in 1896, 1898, 1900, etc.; Artificials in 1895, 1897, 1899, etc.

Plot 14 got 86 lbs. Sul. Am. in 1900.

HAY EXPERIMENTS (SET 1). PLOT = $\frac{1}{20}$TH ACRE.

Average, 1900.	Average, 1899.	Average, 1898.	Average, 1897.	Average, 1896.	Average, 1895.	Total Average in 6 Years.	Increased Produce in 6 Years.	Cost of Manures for 6 Years.	Net Gain or Loss (–) by use of Manures in 6 Years. Hay at 50s. per ton.	Plots.
Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	s.	s.	
21¼	20¾	22½	19	14½	16	114	...	...	...	1
23	25¼	28¼	25	17½	22¼	141¼	27¼	50	18	2
27¾	26½	26	23½	19½	20¾	144	30	43	32	3
23½	23½	25½	24	19	20	135½	21½	27	27	4
29½	24¼	26¼	23½	18¾	20½	142¾	28¾	37	35	5
28¼	27¼	31½	26	24¼	27	164¼	50¼	93	33	6
33½	27½	31¼	28	20½	22	162¾	48¾	87	35	7
33¼	27	30	23	20½	21	154¾	40¾	81	21	8
36½	28½	35½	27¾	22½	26¾	177½	63½	130	29	9
33¼	29¼	35¾	29¼	22¼	25½	175¼	61¼	114	39	10
34½	28¾	34	29½	25¾	25½	178	64	122	38	11
31	26¼	32½	27½	24	23½	164¾	50¾	112	15	12
29¾	27	35	28	26¼	23½	169½	55½	191	–52	13
27½	25	29¾	28¾	20¾	21¼	153	39	56	43	14
30½	36½	34	37¾	23½	27	189¼	75¼	179	9	15
30¼	33	31½	34	21	24½	174	60	150	...	16

Plot 15 gets both Dung and Artificials in alternate years, namely, 1895, 1897, 1899, etc., and nothing in the intervening years. Glasson not included in the average for 1897.

Plot 16 gets Dung alone in alternate years, namely, 1895, 1897, 1899, etc., and nothing in intervening years. (Applied at Glasson in 1900 by mistake.)

TABLE X.—SIXTH CROP OF CUMBER

Plots.	Manuring per Acre for Crops 1895, 1897, 1898, and 1900; nothing for 1896 and 1899.									Produce of Hay per Ac 1900.		
	Nitrate.	Super.	Slag.	Dis. Bones.	Bone Meal.	Fish Meal.	Kainit.	Lime Dust.	Cost per Acre.	Brampton.	Gosforth.	Kirkbampton.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	s. d.	Cwt.	Cwt.	Cwt.
1	...	...	...	...	...	...	...	...	... ...	27¾	22½	32¼
*2	112	392	...	...	...	...	392	...	27 11	35¼	32½	52
3	112	196	...	...	...	...	392	...	22 6	36	27¾	50¾
4	112	588	...	...	...	...	392	...	33 4	35½	31½	44¼
5	112	392	...	...	...	...	196	...	23 10	38½	28¾	38
6	112	392	...	...	...	...	588	...	31 11	40¼	30¼	42¾
7	56	392	...	...	...	...	392	...	23 5	39¼	29¼	41¼
8	168	392	..	...	...	...	392	...	32 5	39½	31	41¼
9	56	...	320	...	...	...	392	...	18 3	43½	34	45¼
10	56	...	480	...	...	...	392	...	21 1	46	30	46½
11	...	...	...	326	...	...	392	...	22 7	37¾	33½	43¾
12	...	...	...	...	248	...	392	...	19 1	33¾	36½	49¼
13	...	...	277	...	...	107	392	...	19 4	36¾	32	47¾
†14	22	78	120	65	50	21	392	...	20 6	42¼	36¾	56½
15	11	39	60	33	25	11	196	...	10 3	39	25	41
16	11	39	60	33	25	11	196	‡560	14 7	40¾	25¼	45¼

* This Mixture supplies 17·5 lbs. Nitrogen, 50 lbs. Phosphoric Acid insoluble Phosphat Super not reckoned), and 50 lbs. Potash per acre.

† One-fifth of the collective dressings of Plots 7, 9, 11, 12 and 13

‡ Contained 500 lbs. Caustic Lime.

Fractions of pounds omitted in stating manures.

PERIMENTS (SET 2). PLOTS, $\frac{1}{20}$TH ACRE.

Average, 1899.	Average, 1898.	Average, 1897.	Average, 1896.	Average, 1895.	Gross Average Yield in 6 Years.	6 Years' Increase due to Manure.	Cost of Manure for 6 Years.	Gain or Loss (−) by use of Manures in 6 Years. Hay at 50s. per Ton.	Plots.
Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	s.	s.	
27½	32¾	28	24½	15¼	155	...	..	...	1
26¾	46¼	40	26¾	24¾	203¾	48¾	105	17	2
24½	44	37½	24¼	24¼	192¾	37¾	85	9	3
25¼	46	42	27½	26½	207¾	52¾	124	8	4
25½	43¼	38¾	24¾	24¼	194¾	39¾	88	11	5
28	47	42¼	26¼	25¼	209¾	54¾	122	15	6
28¼	44½	39	25¼	21¼	196½	41½	88	16	7
30¾	49¼	42½	24¼	24¾	209¾	54¾	122	15	8
30½	44	35	25¾	25	202¾	47¾	74	45	9
30¾	49	37	26¾	25¼	209½	54½	86	50	10
31¼	45¾	38¼	25¾	23½	203	48	93	27	11
32	43¾	37	26¼	21¾	201¾	46¾	78	39	12
29¼	43¼	37¼	27	24¼	201¼	46¼	76	40	13
30¾	45½	40½	28¾	28¾	217¾	62¾	82	75	14
28¾	40½	34¾	25½	22¾	188½	33½	41	43	15
27¼	35¾	31¼	22	20¾	171¾	16¾	59	−17	16

TABLE XI.—SEVENTH CROP OF EXPERIMENT ON

Plots.	Manures applied per Acre to Crops, 1894, 1896, 1897, 1898, 1899, and 1900. Nothing in 1895.								
	Dung.	Sul. Am.	Nitrate of Soda.	Super.	Slag.	Dis. Bones.	Fish Meal.	Kainit.	Lime Dust.
	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	...	...	...	...	...	...	...	...	...
2	...	...	112	...	...	...	...	...	...
3	...	...	...	812	...	...	...	...	...
4	...	...	...	...	...	...	...	560	...
5	...	...	56	406	...	...	...	...	...
6	...	...	56	...	284	...	...	...	...
7	...	...	56	...	...	...	...	280	...
8	...	..	56	406	...	...	...	...	350
9	...	...	56	406	...	...	...	280	...
10	...	...	56	...	284	...	...	280	...
11	...	...	...	406	...	...	...	280	...
12	...	...	37	271	...	...	...	187	...
13	...	...	56	203	142	...	...	280	...
14	...	...	...	...	...	326	...	280	...
15	...	...	...	355	...	...	107	270	...
16	...	43	...	406	...	...	...	280	...
17	...	8$\frac{3}{5}$	22	233	57	65	21	280	...
18	...	4$\frac{3}{10}$	11	117	28	...	11	140	...
19	10	4$\frac{3}{10}$	11	117	28	...	11	140	...
20	10	...	...	...	...	...	...	...	...

NOTES.—The Lime dust for Plot 8 contained 250 lbs. Caustic lime.

One-fifth of dressings of Plots 9, 10, 14, 15, and 16.

In 1894 Plot 14 got 280 lbs. Dissolved Bones, and 280 lbs. Kainit, supplying 8·9 lbs. Nitrog 38 lbs. Phosphoric Acid, and 35 lbs. Potash per acre; the dressings given to the other Plots w based upon these amounts. In 1900 the standard was altered to 8·75 lbs. Nitrogen, 50 Phosphoric Acid, and 35 lbs. Potash per acre for Plot 14, and the same or proportionate quanti for other Plots. In 1894 the "total" phosphates, but in 1900 the "soluble" phosphates only, Super, were reckoned.

D LAND HAY AT SEAHAM, CO. DURHAM.

t of Manures per Acre, 1900.		Yield per Acre of Crop, 1900.	Increase in 7 Years.	Total Cost of Manures in 7 Years.	Net Gain or Loss ( ) in 7 Years.	Plots.
s.	d.	Cwt.	Cwt.	s.	s.	
...		17½	...	...	...	1
9	0	22¾	30¾	52	25	2
21	8	18¾	3¼*	92	−100	3
11	3	17¾	5¾*	69	− 83	4
15	4	24¾	36	72	18	5
10	2	24	16¼	56	− 15	6
10	2	22	9½	62	− 38	7
17	10	22½	11¾	87	− 58	8
21	0	24	19½	117	− 68	9
15	10	26¾	41½	91	13	10
16	6	22¼	22¼	81	− 25	11
14	0	28¾	49¾	71	53	12
18	5	31¼	79½	99	100	13
20	3	30	40¾	116	− 12	14
21	2	27¾	44¾	108	4	15
21	0	25¾	30¾	107	− 30	16
17	0	31¾	56¼	102	39	17
8	6	31¾	70	51	124	18
50	0	35¾	101	234	19	19
50	0	39½	113	200	83	20

* Decrease.

17 gets one-fifth of dressings of Plots 9, 10, 14, 15 and 16. Plot 19 got both Dung and
ls in 1894 and 1896, but Artificials only in 1897. For 1898 it got Dung only, and in future it
Dung and Artificials in alternate years (Artificials 1899, Dung 1900, etc.). Plot 20 got
1894, 1896, and 1898, and in future it will get Dung in alternate years.
valued at 50s. per ton.

TABLE XII.—FIFTH YEAR OF EXPERIMENT ON OLD LAND HAY AT SHIELD ASH, WEARDALE, CO. DURHAM.

Plots.	Manures Applied per Acre for Crops of 1896, 1897, 1898, 1899, and 1900.										Yield per Acre.		Increase in 5 Years.	Net Gain in 5 Years.
	Dung.	Sulphate of Ammonia.	Nitrate of Soda.	Superphosphate.	Slag.	Dissolved Bones.	Bone Meal.	Fish Meal.	Kainit.	Cost per Acre for 5 Years.	1900.	Total for 5 Years.		
	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	s.	Cwt.	Cwt.	Cwt.	s.
1	...	...	...	...	...	...	...	...	...	...	23¾	115½	...	...
2	...	...	51	372	...	...	...	...	...	59	34½	155¼	39¾	40
3	...	...	51	...	...	...	...	...	200	41	33	147¾	32¼	40
4	...	...	...	372	...	...	...	...	200	63	39¾	160½	45	50
5	...	...	51	372	...	...	...	...	200	79	37¾	182½	67	89
6	...	39	...	372	...	...	...	...	200	80	40¼	179¼	63¾	79
7	...	39	...	...	260	...	...	...	200	66	41¼	179½	64	94
8	...	...	...	...	...	300	...	...	200	86	40¼	172¼	56¾	56
9	...	...	...	...	227	...	...	98	200	64	49	208½	93	169
10	...	...	...	...	...	...	206	...	200	69	44½	190	74½	117
11	...	19	13	186	65	75	...	...	200	80	48¼	208	92½	151
12	...	...	...	...	520	...	...	...	...	52	38¾	185¼	69¾	122
13	10	...	...	...	520	...	...	...	...	170	47¼	209½	94	65
14	5	...	...	...	...	...	...	...	...	125	42¾	195¾	80¼	76
15	10	...	...	...	...	...	...	...	...	150	37½	181¼	65¾	14
16	10	19	13	186	65	75	...	...	200	148	50½	224	108½	123

NOTES.—Plot 8 was taken as the Standard Plot in 1895; the 2½ cwt. Dissolved Bones then used, supplied 8·06 lbs. Nitrogen, and 36·4 lbs. Phosphoric Acid, and the 2 cwt. Kainit, 28·8 lbs. Potash. The manures applied to the other plots were based upon these proportions. In 1900 the Dissolved Bones used supplied the same quantity of Nitrogen, but 45·75 lbs. Phosphoric Acid. The quantity of Kainit was altered so as to give 25 lbs. Potash per acre. In the case of Superphosphate the insoluble phosphates have been neglected.

Plot 11 gets one-fourth of the collective Dressings of Plots 5, 6, 7, and 8. Fractions of pounds omitted in stating manuring.

Plot 13 got Dung for 1896, Slag for 1897, and Dung for 1898, and will so continue to receive thes substances in alternate years.

Plot 14 gets 5 tons of Dung annually.

Plot 15 gets 10 tons of Dung in alternate years, beginning with the crop of 1896.

Plot 16 got Artificials for crop 1896, Dung for 1897, Artificials for 1898, and so on in alternate years.

The Hay is valued at 50s. per ton, Dung 5s. per ton.

TABLE XIII.—EIGHTH CROP OF EXPERIMENT ON OLD LAND HAY AT BROOMHAUGH, NORTHUMBERLAND. (B. PLOTS.) PLOTS = $\frac{1}{10}$TH ACRE.

Plots.	Manuring per Acre, 1900.						Yield 1900.	Yield in 8 Years.	Increase in 8 Years over the Unmanured Plot.	Cost of Manures in 8 Years.			Gain or Loss (–) in 8 Years. Hay at 50s. per ton.		
	Dung.	Artificials.													
		Sulphate of Ammonia.	Nitrate of Soda.	Superphosphate.	Slag.	Kainit.									
	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cwt.	Cwt.	Cwt.	£	s.	d.	£	s.	d.
1	...	...	...	...	...	...	8¼	86¼	...		...			...	
2	...	...	112	...	...	...	11	119½	33¼	2	17	0	1	6	0
3	...	...	...	...	392	...	11	113	26¾	2	16	0	0	11	0
4	...	...	...	...	...	280	7¼	82	*4¼	2	11	0	–3	3	0
5	...	...	112	...	392	...	14	141¼	55	5	13	0	1	5	0
6	...	...	112	...	...	280	11¾	115¾	29½	5	8	0	–1	13	0
7	...	...	...	...	392	280	26½	183½	97¼	5	8	0	6	15	0
8	...	...	112	...	392	280	25¼	215¼	129	8	5	0	7	17	6
9	...	84	...	...	392	280	22¼	153¼	67	8	1	0	0	6	6
10	...	...	112	252	...	280	23	161¼	75	7	13	0	1	15	6
11	10	...	...	...	...	...	25	214	127¾	12	10	0	3	9	4

* Decrease.

NOTES.—In 1893 and 1894 the artificial dressings were 4½ cwt. Slag, 3 cwt. Superphosphate and 5 cwt. Kainit. No manure was applied in 1895. The above quantities of Artificials have been applied annually since 1896.

Plot 11 got 10 tons Dung per acre in 1893, 1894, 1896, 1898, and 1900.

TABLE XIV.—EIGHTH CROP OF OLD LAND HAY AT BROOMHAUGH NORTHUMBERLAND A. PLOTS.

Plots.	Manuring Per Acre.					Yield 1894.	Botanical Analysis, 1894.			Yield 1900.	Botanical Analysis, 1900.		
	Sulphate of Ammonia.	Nitrate of Soda.	Super.	Slag.	Kainit		Leguminosæ.	Gramineæ.	Various.		Leguminosæ.	Gramineæ.	Various.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cwt.	%	%	%	Cwt.	%	%	%
1	…	…	…	…	…	17½	8·1	69·8	22·1	23	8·7	69·8	21·5
2	…	112	…	…	…	21	7·6	74·0	18·4	25¾	4·3	82·0	13·7
3	…	…	…	392	…	28¼	10·4	73·2	16·4	23¾	7·3	76·7	16·0
4	…	…	…	…	280	17½	15·8	67·2	17·0	23¼	10·0	68·3	21·7
5	…	112	…	392	…	30¼	18·2	64·8	17·0	21¾	10·2	73·3	16·5
6	…	112	…	…	280	25¾	8·0	77·8	14·2	26	9·6	70·5	19·9
7	…	…	…	392	280	35	29·2	59·4	11·4	26¾	4·7	82·5	12·8
8	…	112	…	392	280	40¼	16·8	71·2	12·0	27	6·5	82·3	11·2
9	84	…	…	392	280	39¾	16·4	75·2	8·4	28¼	5·8	82·4	11·8
10	…	112	252	…	280	36¾	14·9	78·3	6·8	23	5·5	83·6	10·9

TABLE XV.—COMPOSITION OF TURNIPS FROM COCKLE PARK, JANUARY, 1900

	Monarch Swedes.														Yellow Turnips.		
	A. F.Y. Manure.		Artificial Manure.		C. F.Y. Manure and Artificials.		D. F.Y. Manure and Artificials.		Averages.				Average.		Miniature Farms.		
	Small.	Large.	Small.	Large.	Small.	Large.	Small.	Large.	A.	B.	C.	D.	Small.	Large	Small	Large.	Average
Water (dried at 60° C.)	88·59	90·34	89·23	89·63	89·36	90·01	89·45	90·41	89·47	89·43	89·69	89·93	89·16	90·10	89·89	91·48	90·69
Amides, etc.	·57	·57	·36	·34	·61	·48	·52	·46	·57	·35	·54	·49	·52	·46	·47	·52	·49
Albuminoids	·47	·57	·54	·48	·56	·58	·63	·63	·52	·51	·57	·63	·55	·56	·61	·56	·59
Sugars (as $C_6H_{12}O_6$)	6·14	4·21	5·67	5·43	5·29	5·02	5·11	4·34	5·17	5·55	5·15	4·72	5·55	4·75	4·02	3·23	3·62
Pectins, etc.	2·70	2·68	2·60	2·48	2·49	2·32	2·67	2·72	2·69	2·54	2·41	2·70	2·61	2·55	2·86	2·36	2·61
Woody Fibre	·96	1·07	1·07	1·11	1·09	1·03	·95	·82	1·01	1·09	1·06	·88	1·02	1·01	1·35	1·11	1·23
Ash	·57	·56	·53	·53	·60	·56	·67	·62	5·7	·53	·58	·65	·59	·57	·80	·74	·77
Total Nitrogen	·167	·183	·145	·132	·170	·169	·183	·175	·175	·138	·170	·179	·166	·165	·173	·172	·173
Sand ...	·09	·05	·07	·07	·03	·02	·11	·11	·07	·07	·03	·11	·07	·06	·08	·05	·06

A, B and C were grown on Cockle Park. D, grown at Longniddry with same manures as C.

TABLE XVI.—INFLUENCE OF MANURES AND SOIL

LOT I.—10 Sheep fed on Swedes manured with 7½ to 9 tons of Farmyard manure per acre.								LOT II.—10 Sheep fed on Swedes manured with 2 cwt Sulph. Am., 10 cwt. Super., and 5 cwt. Kainit. per acre.						
No. of each Sheep.	Breed.	Live weight (unfasted).						No. of each Sheep.	Breed.	Live weight (unfasted).				
		January 2.	February 6.	February 26.	March 19.	April 9.	Total increase.			January 2.	February 6.	February 26.	March 19.	April 9.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs			Lbs.	Lbs	Lbs.	Lbs.	Lbs
11	B.L. and Mule Hg.	85	103	111	122	128	43	47	Shearling	113	131	137	143	151
6	Shearling	109	121	128	135	142	33	76	Shearling	110	116	123	136	146
101	H.B. Hogg ..	85	88	100	105	115	30	155	H.B. Hogg ..	87	101	105	114	117
9	Shearling	109	111	120	127	138	29	86	B.L. and H.B. Hg.	101	112	116	123	130
44	Shearling	116	119	127	127	137	21	1	Shearling	116	121	129	141	142
98	B.L. and H.B. Hg.	101	110	115	124	121	20	8	Shearling	118	124	128	135	143
82	Shearling	125	129	129	134	144	19	97	B.L. and H.B. Hg.	86	93	98	103	109
77	B.L. and H.B. Hg.	91	96	96	102	109	18	12	B.L. and Mule Hg.	93	95	96	102	108
138	H. B. Hogg ..	109	112	113	119	124	15	38	H.B. Hogg ..	88	87	91	98	103
80	B.L. and Mule Hg.	89	88	92	99	102	13	35	B.L. and Mule Hg.	106	116	116	112	120
	Average	101·9	107·7	113·1	119·4	126	24·1		Average	101·8	109·6	113·9	120·7	126·9

NOTES.—From January 2nd to February 6th, that is for five weeks, the Sheep were fed on Swedes only they ate about 15 lbs. per head daily. Thereafter until April 9th, that is for nine weeks, the Sheep ate 16 lb Swedes and ½ lb. Meadow Hay per head daily, with ¼ lb. Decorticated Cotton Cake for six weeks, and ½ lb. daily for the last three weeks. The total amount of food eaten by each lot in fourteen weeks gave the following allow-

EEDING VALUE OF SWEDES, COCKLE PARK, 1900.

I.—10 Sheep fed on Swedes grown with 7½ tons ard manure, 1 cwt. Sulph. Am., 5 cwt. Super. and 2½ cwt. Kainit.							LOT IV.—10 Sheep fed on Swedes grown in East Lothian and manured as for Lot III.							
Breed.	Live weight (unfasted).						No. of each Sheep.	Breed.	Live weight (unfasted).					
	January 2.	February 6.	February 26.	March 19.	April 9.	Total increase.			January 2	February 6.	February 26.	March 19.	April 9.	Total increase.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs
nd Mule Hg.	101	110	116	125	133	32	109	Shearling	111	120	125	134	148	37
ling	112	119	130	136	142	30	36	B.L. and Mule Hg.	100	109	118	124	132	32
ling	139	151	152	155	168	29	41	Shearling	116	119	129	135	144	28
nd H.B. Hg.	83	90	98	108	109	26	79	B.L. and Mule Hg.	95	104	107	114	123	28
nd H.B. Hg.	98	97	103	112	123	25	37	H.B. Hogg ..	83	88	91	97	105	22
Hogg ..	80	81	86	94	103	23	18	B.L. and H.B. Hg.	98	99	107	113	120	22
ling .. .	115	122	122	126	137	22	112	Shearling	117	125	132	126	136	19
nd Mule Hg.	99	103	108	115	121	22	82	B.L. and H.B. Hg.	97	111	110	108	109	12
Hogg. ..	77	74	84	92	98	21	89	H.B. Hogg ..	88	87	88	95	99	11
ling	113	121	125	128	133	20	22	Shearling	113	119	110	115	124	11
Average	101·7	106·8	112·4	119·1	126·7	25·0		Average	101·8	108·1	111·7	116·1	124	22·2

r sheep:—1,528 lbs. Swedes (worth 5s. 5½d., at 8s. per ton), 15¾ lbs. Hay (4½d.), and 21 lbs. Cake (1s. 3¾d.). A
st of 7s. 1½d., or just over 6d. per week.

eep No. 22 in Lot IV was off its feed for a week in February.

B.L." = Border Leicester. "H.B." = Half-bred between Border Leicester and Cheviot.

TABLE XVII.—INFLUENCE OF MANURES O

Lot I.—10 Sheep fed on Hay manured with 7 cwt. Basic Slag and 4 cwt. Kainit per acre.								Lot II.—10 Sheep fed on Hay manured 1¼ cwt. Nitrate of Soda, 7 cwt. Basic S 4 cwt. Kainit per acre.				
No. of individual Sheep.	Breed.	Live weight (unfasted).						No. of individual Sheep.	Breed.	Live weight (		
		January 2.	February 6.	February 26.	March 19.	Increase.				January 2.	February 6.	February 26.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs				Lbs.	Lbs.	Lbs.
103B	Shearling	117	130	132	136	19		2A	S. and Mule Hogg	97	96	104
34A	S. and Mule Hogg	100	103	106	117	17		8A	S. and Mule Hogg	96	97	102
83A	Shearling	112	117	125	128	16		78B	Shearling	118	122	122
93A	S. and H.B. Hogg	88	93	98	101	13		81B	Shearling	125	129	130
91B	S. and H.B. Hogg	118	120	126	131	13		12B	B.L. and Mule Hg.	95	95	109
88B	S. and Mule Hogg	89	92	94	98	9		53B	S. and Mule Hogg	88	90	92
50A	S. and Mule Hogg	96	92	98	104	8		51A	S. and H.B. Hogg	92	89	95
75A	Shearling	133	135	143	141	8		78A	B.L. and H.B. Hg.	100	102	101
73B	S. and Mule Hogg	88	85	88	92	4		88B	Shearling	122	124	126
98B	Shearling	118	123	125	122	4		58A	Shearling	124	127	129
	Average	105·9	109	113·5	117	11·1			Average	105·7	107·1	110
	Do. of Pen A ..	105·8	108	114	118·2	12·4			Do. of Pen A ..	105·4	106·2	110
	Do. of Pen B ..	106	110	113	115·8	9·8			Do. of Pen B ..	106	108	109

Notes.—For five weeks from January 2nd to February 6th the Sheep received 8 lbs. S
head daily and Hay *ad lib.* Lot I. ate 1·73 lbs., Lot II. 1·56 lbs., Lot III. 1·78 lbs., and Lot IV.
per head per day. For the next six weeks until March 19th the Sheep received 1 lb. Hay, 10 lbs.
¼ lb. Maize Meal, and ¼ lb. Decorticated Cotton Cake. From the food eaten by each Lot the
head for eleven weeks amounts to 700 lbs. Swedes (2s. 6d.), 21 lbs. Cake and Meal (1s. 2d.), and

ING VALUE OF SEEDS HAY, COCKLE PARK, 1900.

Lot III.—10 Sheep fed on Hay manured with ¾ cwt. Sulphate of Ammonia, 7 cwt. Slag, 4 cwt. Kainit.							Lot IV.—10 Sheep fed on Hay manured with 1½ cwt. Sulphate of Ammonia, 7 cwt. Slag, 4 cwt. Kainit.					
	Live weight (unfasted).							Live weight (unfasted).				
Breed.	January 2.	February 6.	February 26.	March 19.	Increase.	No. of individual Sheep.	Breed.	January 2.	February 6.	February 26.	March 19.	Increase.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs			Lbs.	Lbs.	Lbs.	Lbs.	Lbs
and Mule Hogg	103	108	111	121	18	17A	Shearling	136	135	145	156	20
and H.B. Hogg	96	96	102	111	15	113A	Shearling	115	119	125	131	16
S. and Mule Hogg	80	82	87	94	14	7B	S. and Mule Hogg	99	99	111	115	16
arling	125	129	136	139	14	22B	S. and Mule Hogg	93	98	100	106	13
rling	124	130	133	138	14	20A	S. and Mule Hogg	87	88	95	100	13
and H.B. Hogg	84	89	91	96	12	28A	S. and H.B. Hogg	92	90	99	101	9
S. and Mule Hogg	104	107	108	113	9	37B	Shearling	122	127	126	131	9
S. and Mule Hogg	86	90	90	94	8	33B	S. and Mule Hogg	94	93	95	102	8
arling	113	116	109	120	7	94B	Shearling	123	127	126	130	7
arling	143	145	148	149	6	16A	S. and Mule Hogg	97	96	95	100	3
Average	105·8	105·2	111·9	117·5	11·7		Average	105·8	107·2	111·7	117·2	11·4
Do. of Pen A ..	105·6	109	113·8	120·6	15·0		Do. of Pen A ..	105·4	105·6	111·8	117·6	12·2
Do. of Pen B ..	106	109·4	110	114·4	8·4		Do. of Pen B ..	106·2	108·8	111·6	116·8	10·6

bs., 105 lbs. and 100 lbs. Hay, respectively (costing from 2s. 7d. to 2s. 10d. at 3s. per cwt.). The average of the keep of one sheep for 11 weeks was, Lot I. 6s. 5d., Lot II. 6s. 3d., Lot III. 6s. 6d., and Lot IV. 4d.

Sheep numbered "A" were fed inside, those marked "B" outside. "S." = Suffolk. "H.B." = Half-d between Border Leicester and Cheviot. The Shearlings were half-bred.

TABLE XVIII.—COMPOSITION OF FIRST YEAR SEEDS HAY* FROM TOWER HILL, COCKLE PARK, 1899.

	Ref. No. 259 Plots 1 and 9. 7 cwt. Diss. Bones. 4 cwt. Kainit.	Ref. No. 260 Plots 2 and 10. 1¾ cwt. Sul. Am. 7 cwt. Slag. 4 cwt. Kainit.	Ref. No. 261 Plots 3 and 11. 1¼ cwt. Nit. Soda. 7 cwt. Slag. 4 cwt. Kainit.	Ref. No. 262 Plots 4 and 12. ⅞ cwt. Sul. Am. 7 cwt. Slag. 4 cwt. Kainit.	Ref. No. 263 Plots 6 and 13. 7 cwt. Slag. 4 cwt. Kainit.
Amides ...	1·52	1·21	0·96	0·98	0·77
Albuminoids .	8·46	5·76	6·78	8·68	10·60
Carbohydrates	49·70	52·12	51·11	50·20	51·98
Woody fibre ...	32·33	33·54	34·40	32·34	27·63
Ash	7·99	7·37	6·75	7·80	9·02
	100·00	100 00	100·00	100·00	100·00
Nitrogen ...	1·60	1·12	1·24	1·55	1·82
Silica	2·71	2·98	2·53	2·31	2·80

* Dried at 100° C.

AT COCKLE PARK. RESULTS PER ACRE FOR THE GRAZING SEASONS OF 1897, 1898, 1899, and 1900.

In 1897 each plot was grazed by eight Sheep for 16 weeks (June 21st to Oct. 11th). In 1898 eight Sheep were, on May 16th, placed on Plots 2, 4, 5, 7, 8, 9, 10; six on Plot 6; and ten on Plots 1 and 3. On June 27th another sheep was added to those Plots 1 and 7, while two were added to those on Plots 3, 9, 10. The Grazing Season of 1898 extended to 20 weeks (May 16th to Oct. 3rd). On May 4th, 1899, six Sheep were placed on Plots 2 and 6; eight Sheep on Plots 1, 4, 5, 7, 8, 9, 10; and twelve Sheep on Plot 3. No alterations were made during the Season, which extended to 20 weeks (May 4th to Sept. 21st). On May 23rd, 1900, six Sheep were placed on Plots 2 and 6, eight on Plots 1 and 11, and 9 on each of the remaining plots. On June 20th three additional Sheep were put on Plot 3; on July 18th one was put on Plot 4, and two on Plot 8. Deducting wool the Sheep cost per head 29s. in 1897, 25s. in 1898. 32s. 6d. in 1899 and 34s. 6d. in 1900.

Plots.	Treatment per Acre in 4 years.	Cost of Treatment per Acre in 4 years.	Live weight increase in:					Live Weight increase in 4 years in excess of Plot 6.		Butcher's valuation per Sheep at the end of each Season.				Butcher's Valuation in excess of Plot 6 in 4 years.	Net Gain (+) or Loss (−) per Acre in 4 years as determined by:		Live Weight gain per Sheep per week during the Season.				Plots.
			1897	1898	1899	1900	Total.	Wgt. in lbs.	Value at 3½d. per lb.	1897	1898	1899	1900	Per Acre.	(a) Weight.	(b) Butcher.	1897	1898	1899	1900	
		s. d.	lbs.	lbs.	lbs.	lbs.	lbs.		s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.					
1	Total of 5⅓ cwt. Dec. Cot. Cake eaten by Sheep in 1897 and 1898 (= 42 lbs. Nitrogen) nothing since	32 6	80	144	106	80	410	228	71 3	36 0	31 0	36 0	34 0	64 3	+ 38 9	31 9	1·9	2·0	2·0	1·5	1
2	4 Tons Common Lime for 1897, nothing since	52 0	32	64	47	60	203	21	6 7	32 0	24 0	31 0	36 0	21 4	− 45 5	− 30 8	0·7	1·2	1·1	1·5	2
3	10 Cwt. Basic Slag (200 lbs. Ph. Ac.) for 1897, nothing since	22 0	77	171	211	131	590	408	127 6	33 0	34 0	38 0	36 0	89 0	+105 6	+ 67 0	1·8	2·2	2·6	1·7	3
4	5 Cwt. Basic Slag (100 lbs. Ph. Ac.) for 1897, and again for 1900	22 0	44	113	113	139	409	227	70 11	30 0	33 0	35 0	38 0	57 9	+ 48 11	+ 35 9	1·0	2·1	2·1	2·2	4
5	7 Cwt. Super. (100 lbs. Ph. Ac.) for 1897, and again for 1900	36 4	56	104	103	137	400	218	68 1	32 0	30 6	33 0	39 0	53 6	+ 31 9	+ 17 2	1·3	1·9	1·9	2·3	5
6	Untreated throughout	—	37	53	48	44	182	—	—	26 0	28 0	28 0	32 0	—	—	—	0·9	1·3	1·2	1·1	6
7	7 Cwt. Super. and 1½ cwt. Sulph. Potash (= 50 lbs. Potash) for 1897, Potash repeated for 1899 and the Super. for 1900	51 8	72	121	107	137	437	255	79 8	32 0	33 0	35 0	38 0	64 9	+ 28 0	+ 13 1	1·7	2·1	2·0	2·3	7
8	7 Cwt. Super. and ½ ton Ground Lime for 1897, Lime repeated for 1899, and the Super. for 1900	56 4	69	119	114	159	461	279	87 2	33 0	32 0	38 0	39 0	75 5	+ 30 10	+ 19 1	1·6	2·2	2·1	2·4	8
9	7 Cwt. Super. and 97 lbs. Sulph. Ammonia (= 20 lbs. N.) for 1897, 70 lbs. Sulph. Ammonia (= 14 lbs. N.) for 1899, the Super. repeated for 1900, with 84 lbs. Sulph. Ammonia (= 16·8 lbs. N.)	59 0	79	94	109	128	410	228	71 3	33 0	30 0	34 0	36 6	52 6	+ 12 3	− 6 6	1·8	1·5	2·0	2·1	9
10	6 Cwt. Dis. Bones (= 100 lbs. Ph. Ac. and 17 lbs. N.) for 1897, and again for 1900 (100 lbs. Ph. Ac. and 16·8 lbs. N.)	61 2	59	117	106	134	416	234	73 1	34 0	32 0	33 0	38 0	62 4	+ 11 11	+ 1 0	1·4	1·9	2·0	2·2	10
11	15 Cwt. Basic Slag (300 lbs. Ph. Ac.) for 1900	33 0	—	66	53	89	—	—	—	—	—	—	—	—	—	—	—	1·6	1·3	2·1	11

TABLE XX.—INFLUENCE OF MANURES ON THE PRODUCTION OF HAY IN THE TREE FIELD, COCKLE PARK. RESULTS PER ACRE FOR THE SEASONS OF 1897, 1898, 1899 AND 1900.

Plots.	Treatment per Acre in 4 years.	Weight of Hay in:					Increased Yield in Four Years.	Net Gain or Loss (–) in Four Years.	Percentage Composition of the Hay of 1900, as regards the undernoted plants.											Plots.
		1897.	1898.	1899.	1900.	Total.			Agrostis sp.	Avena flavescens.	Cynosurus cristatus.	Dactylis glomerata.	Festuca sp.	Holcus lanatus.	Plantago lanceolata.	Triodia decumbens.	Trifolium repens.	Lathyrus pratensis.	Lotus corniculatus.	
		Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	s. d.												
1	**Total of 5⅓ cwt. Dec. Cot. Cake eaten by Sheep in 1897 and 1898 (=42 lbs. Nitrogen) nothing since**	25¾	18½	18¾	20¾	83¾	34¼	?	60·7	3·5	6·3	3·0	—	8·7	1·5	1·6	2·1	—	2·1	1
2	4 Tons Common Lime for 1897, nothing since	20¾	16¼	12½	17½	67	17½	–25 9	53·7	8·8	9·1	2·9	1·9	3·7	1·1	3·6	1·6	—	2·3	2
3	10 Cwt. Basic Slag (200 lbs. Ph. Ac.) for 1897, nothing since	22½	32¼	30½	28¾	114	64½	74 9	44·1	5·0	9·9	7·7	·3	15·2	·5	·5	5·1	3·6	1·2	3
4	5 Cwt. Basic Slag (100 lbs. Ph. Ac.) for 1897, and again for 1900	16	32	24½	24¾	97¼	47¾	49 7	33·2	5·7	2·5	4·3	·2	6·8	·9	1·4	22·1	5·6	4·3	4
5	7 Cwt. Super. (100 lbs. Ph. Ac.) for 1897, and again for 1900	23¾	22¼	17½	29	92½	43	28 2	39·5	·2	1·4	3·2	·1	9·9	·2	2·0	14·6	19·8	1·6	5
6	Untreated throughout ..	22¼	13½	7½	6¼	49½	—	—	58·5	·6	2·2	·3	1·4	3·7	·8	15·1	·4	·1	2·4	6
7	7 Cwt. Super. and 1½ cwt. Sulph. Potash (=50 lbs. Potash) for 1897, Potash repeated for 1899 and the Super. for 1900	17½	17	20¾	26	81¼	31¾	– 4 1	38·2	2·8	1·5	10·9	1·3	8·0	1·3	2·2	13·4	3·8	10·1	7
8	7 Cwt. Super. and ½ ton Ground Lime for 1897, Lime repeated for 1899, and the Super. for 1900	24¾	20¾	18¼	30¼	94	44½	9 7	28·6	5·9	3·8	3·7	·5	10·6	1·0	·6	24·4*	3·9	13·1	8
9	7 Cwt. Super. and 97 lbs. Sulph. Ammonia (=20 lbs. N.) for 1897, 70 lbs. Sulph. Ammonia (=14 lbs. N.) for 1899, the Super. repeated for 1900, with 84 lbs. Sulph. Ammonia (=16·8 lbs. N.)	27½	21½	18¼	34	101¼	51¾	18 7	24·2	2·1	11·0	6·8	·4	20·6	·2	3·1	9·7	9·6	6·8	9
10	6 Cwt. Dis Bones (=100 lbs. Ph. Ac. and 17 lbs. N.) for 1897, and again for 1900 (100 lbs. Ph. Ac. and 16·8 lbs. N.)	26	3¾	17½	29¼	96½	47	9 4	18·7	5·6	6·9	4·1	·1	17·8	1·6	2·7	10·7	—	18·3	10
11	**15 Cwt. Basic Slag (300 lbs. Ph. Ac.) for 1900**	—	—	—	23¾	—	—	—	40·6	1·9	1·6	3·3	—	6·1	2·2	3·5	9·3	2·6	15·5†	11

* 1·0 Trifolium procumbens. † ·4 Lotus major.

TABLE XXI.—COMPOSITION OF HAY FROM TREE FIELD, COCKLE PARK, 1899.

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9.	Plot 10
Sample as received—										
Moisture	8·65	13·32	12·75	12·44	11·22	11·20	12·34	12·16	11·53	11·77
Sample dried at 100°C—										
Amides	·88	·91	1·2	·92	1·06	·56	·98	·79	1·01	·93
Albuminoids	7·47	7·29	10·19	9·96	9·87	7·22	9·95	8·97	10·64	9·89
Carbohydrates, &c.	53·40	53·43	51·46	52·85	54·89	54·54	54·20	54·54	53·25	54·06
Woody fibre	31·20	29·61	29·35	28·54	26·54	30·91	26·73	27·37	27·13	26·23
Ash	7·05	8·76	7·71	7·73	7·64	6·77	8·14	8·33	7·97	8·89
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Silica, &c.	2·52	3·84	2·21	2·63	2·60	3·20	2·65	3·70	3·14	2·86
Potash (K O)	2·27	1·92	2·66	2·23	1·94	1·63	2·43	2·18	2·12	2·03
Phosphoric Acid (P_2O_5)	·30	·22	·47	·39	·38	·21	·44	·32	·44	·34
Lime (CaO)	·53	·62	·80	·86	·65	·40	·94	·90	·97	·80
Nitrogen (N	1·34	1·31	1·84	1·74	1·75	1·24	1·75	1·56	1·87	1·73

TABLE XXII.—RESULTS OF A ROTATION EXPER
EACH PLOT MEASURES ¼ ACRE, EXCE

Plots.	Manuring per Acre for Turnips, 1897.				Manuring per Acre for Oats, 1898.			Manuring per Acre for Seeds Hay, 1899.				Manuring per Acre for Oats, 1900.		
	Dung.	Sulphate of Ammonia.	Super-phosphate.	Sulphate of Potash.	Sulphate of Ammonia.	Super-phosphate.	Sulphate of Potash.	Dung.	Sulphate of Ammonia.	Super-phosphate.	Sulphate of Potash.	Sulphate of Ammonia.	Super-phosphate.	Sulphate of
	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lb
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	...	112	560	112	...	...	...	10	...	...	...	...	...	...
3	5	56	280	56	...	...	...	5	56	280	56	...	...	...
4	...	112	560	112	...	...	...	...	...	...	...	...	...	...
5	...	112	560	112	...	...	...	...	...	...	...	...	...	...
6	...	112	560	112	...	...	...	...	...	...	...	...	...	...
7	...	112	560	112	...	...	...	...	56	280	112	56	280	...
8	...	112	560	112	...	...	...	...	112	560	112	...	...	...
9	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	...	112	560	...	...	...	...	...	112	560	...	...	...	...
11	...	224	1,120	224	...	...	...	...	...	...	...	...	...	...
12	...	224	1,120	224	...	...	...	...	112	560	112	...	...	...
13	...	224	1,120	224	112	...	...	...	112	560	112	112	...	...
14	..	112	560	112	37	187	37	...	37	187	37	37	187	37
15	10	...	...	...	...	...	...	...	...	...	...	...	...	...
16	10	112	560	112	...	...	...	...	...	...	...	...	...	...
17	10	...	...	...	...	...	...	...	112	560	112	...	...	...
18	10	56	280	56		...	...	...	56	280	56	...	...	...
19	10	56	280	56	19	93	19	...	19	93	19	19	93	19
20	10	28	140	28	28	140	28	...	28	140	28	28	140	28
21	10	...	...	...	19	187	19	...	19	187	19	19	187	19
22	20	...	...	...	19	187	19	...	19	187	19	19	187	19

NOTES.—Plot 2. The dressing for this and for other plots getting the same quantity of Artificials, contained 23 lbs. Nitrogen, 75 lbs Phosphoric Acid, and 50 lbs. Potash.

Plots 5, 6 and 7. Half the turnips eaten on the land by sheep. The sheep on Plot 5 ate 14½ cwt. hay, and on Plots 6 and 7, 15½ cwt. of hay and 11½ cwt. Linseed Cake per acre.

IN BACK HOUSE FIELD, COCKLE PARK.

AND 9, WHICH ARE ONLY ⅛ ACRE.

s, 1897.		Oats, 1898.					Hay, 1899.			Oats, 1900.					Total Value of the Crops in Four Years.		Plots.
Value at 7s. per Ton.		Yield of Good Grain.	Weight per Bushel.	Yield of Straw.	Value Grain at 20s. per Qr. and Straw at 35s. per Ton.		Yield per Acre.	Value at £3 per Ton.		Yield of Good Grain.	Weight per Bushel.	Yield of Straw.	Value Grain at 20s per Qr. and Straw at 35s. per Ton.				
£	s.	Bush. of 42lbs	Lbs.	Cwt.	£	s.	Cwt.	£	s.	Bush. of 42lbs.	Lbs.	Cwt.	£	s.	£	s.	
3	10	33¼	41	21¼	6	0	16¼	2	9	31	40	16½	5	7	17	6	1
5	12	40¼	41¾	25½	7	6	24¾	3	14	31	41	17¾	5	9	22	1	2
5	10	48¼	41	32¾	8	18	32¼	4	18	32½	41	18¾	5	14	25	0	3
5	5	44¼	40	27	7	18	16¼	2	9	30¾	39½	17¼	5	7	20	19	4
5	12	56¾	40½	37¾	10	8	19½	2	19	37½	40½	18¾	6	7	25	6	5
5	16	69¾	41	45½	12	14	20	3	0	36¼	40	20½	6	7	27	17	6
6	0	69¾	42¾	45½	12	14	26¾	4	0	39¾	40½	25¾	7	4	29	18	7
5	2	50¼	41¼	31¼	9	1	28¾	4	6	33	39½	21½	6	0	24	9	8
0	17	41	42	26¼	7	9	15½	2	7	32¾	39½	21½	6	0	16	13	9
1	14	51¾	42½	31¼	9	4	26¼	3	19	33¼	39½	15¼	5	10	20	7	10
6	8	50¾	42	31¾	9	3	15¾	2	7	30½	39	16¾	5	5	23	3	11
6	0	46¾	42½	28¼	8	6	28½	4	6	31½	40	15	5	5	23	17	12
5	12	55¼	42½	34	9	18	29¼	4	8	44¾	39	25¼	7	16	27	14	13
5	4	50¼	42½	30¾	9	0	21¾	3	5	39¾	37½	26¾	7	6	24	15	14
5	9	58¼	42½	36¾	10	10	25½	3	17	44¾	40	27¾	8	0	27	16	15
6	0	59¼	43	36¾	10	12	27½	4	3	45	38	26	7	18	28	13	16
5	7	56¼	43	37¾	10	7	38½	5	16	43¾	39½	27	7	16	29	6	17
5	13	53¼	42	36	9	16	32¾	4	18	38	38¼	24½	6	18	27	5	18
5	8	62	42	41¼	11	8	29	4	7	41	40¼	25½	7	5	28	8	19
4	8	62	42	40¼	11	6	28¾	4	6	40½	40¼	26	7	7	27	7	20
4	13	60	42	41	11	2	26⅜	4	0	43½	40	23¾	7	11	27	6	21
4	8	66¾	41	45¼	12	6	36½	5	10	44½	40¼	25¼	7	15	29	19	22

The drills on this plot were 21¼ inches wide, on the other plots they were 27 inches

14, 19, 21 and 22. The weights of Artificials have been given to the nearest pound.

TABLE XXIII.—EXPERIMENT ON SEEDS HAY IN TOWER HILL FIELD, COCKLE PARK. PLOTS, ¼ ACRE.

Plots.	Treatment per Acre.					Cost of Manure.		Yield.			Botanical Composition of First Cut of Hay Per Cent.			
	Sul. Am.	Nit. of Soda.	Super.	Slag.	Kainit.			1st Crop.	2nd Crop.	Total.	Leguminosæ.	Gramineæ.	Weeds.	Seeds, dirt, &c.
						s.	d.	Cwt.	Cwt.	Cwt.				
1 A.	..	224	448	..	252	36	0	53¾	24	77¾	62·1	37·1	..	·8
2 ,,	..	224	..	616	252	33	0	52	23¾	75¾	46·8	51·3	·1	1·8
3 ,,	..	..	..	616	252	15	0	48¾	24	72¾	73·1	26·0	..	·9
4 ,,	..	224	..	616	..	28	0	50	22½	72½	32·0	66·0	·3	1·7
5 ,,	..	224	..	..	252	23	0	50¼	16¾	67	29·7	69·0	..	1·3
6 ,,	..	..	..	..	..	..		47½	18	65½	54·1	43·8	·5	1·6
1 B.	168	..	448	..	252	36	0	48¾	17¾	66½	24·7	72·0	·8	2·5
2 ,,	168	..	..	616	252	33	0	39½	17¾	57¼	24·4	74·2	..	1·4
3 ,,	..	..	..	616	252	15	0	36	19¼	55¼	48·4	49·8	·3	1·5
4 ,,	168	..	..	616	..	28	0	37¼	16¾	54	32·3	66·0	..	1·7
5 ,,	168	..	..	..	252	23	0	28½	13¾	42¼	33·0	65·9	..	1·1
6 ,,	..	..	..	..	..	..		20	18	38	56·1	42·3	..	1·6

NOTE.—The Nitrate and Sulphate supplied 35 lbs. Nitrogen, the Kainit 30 lbs. Potash, and the Phosphatic manures 75 lbs. Phos. Acid per acre; the Super. used was a "high class," the Slag a "low class."

TABLE XXIV.—TEST OF 10 VARIETIES OF POTATO IN EAST TOWER HILL, COCKLE PARK. PLOTS, 1/20 ACRE.

Plots.	Treatment per Acre.	Yield per Acre.							
		Large.		Sets.		Small.	Diseased.	Total.	
		T.	cwt.	T.	cwt.	Cwt.	Cwt.	T.	cwt.
1 and 10	Maincrop	2	13¾	1	16	10¾	¾	5	1¼
2 „ 11	British Queen	4	12¾	2	4½	23½	1¾	8	2½
3 „ 12	Up-to-Date	5	17¾	1	7¼	16½	¾	8	2¼
4 „ 13	Garton	4	14¾	1	9	21	3	7	7¾
5 „ 14	Abundance	3	9	1	13	14¾	1½	5	18¼
6 „ 15	British Lion	5	17½	0	16½	8½	1¼	7	3¾
7 „ 16	Windsor Castle ...	3	17½	1	0¼	14¾	1	5	13½
8 „ 17	General Kitchener ...	4	12½	1	10¼	13¼	5¼	7	1¼
9 „ 18	Dean Kitchin	5	8	1	3	9½	¾	7	1¼

NOTES.—Each variety occupied two plots. All were planted on May 1st, and were manured alike with 12 tons Fold Manure, 1 cwt. Nitrate of Soda, 1 cwt. Sulphate of Ammonia, 3 cwt. Superphosphate, and 4 cwt. Kainit per acre.

TABLE XXV.—EXPERIMENT ON THE MANURING OF POTATOES IN BACK HOUSE FIELD.

COCKLE PARK. Quantities stated per acre.

Plot.	Manuring.									Yield when lifted. (November.)			Yield as taken from pit. (March.)					Percentage of Dry Matter.
	Dung	Sulp. Amm.	Nit. Soda.	Super.	Slag.	Sulp. Pot.	Mur. Pot.	Kainit.	Fish Meal.	Large and Sets.		Small.	Large.		Sets.		Dis-eased.	
	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	T.	cwt.	Cwt.	T.	cwt.	T.	cwt.	Cwt.	
1	12	...	...	...	...	...	...	...	...	10	13	17	8	5	0	15	6¾	22·31
2	12	84	56	150	...	250	...	...	...	12	15	6	9	17¾	0	15¾	6½	...
3	12	...	...	150	...	250	...	...	...	12	1	10	...		...		...	...
4	12	84	56	...	...	250	...	...	...	11	12	12	...		...		...	...
5	12	84	56	150	...	...	...	...	...	13	3	7	...		...		...	...
6	12	168	112	150	...	250	...	...	...	12	6	5	9	3¼	1	0	6	...
7	12	84	56	300	...	250	...	...	...	11	18	20	8	13½	1	7¼	7¼	...
8	12	84	56	150	...	500	...	...	...	12	7	10	8	6	1	9¼	8¼	...
9	12	84	56	150	...	...	103	...	...	12	7	8	8	1½	1	17¼	7¼	...
10	12	84	56	150	...	...	...	400	...	11	11	6	8	5¾	1	10	5	...
11	...	...	...	...	...	...	...	...	...	6	12	9	3	19¼	1	15¾	½	25·4
12	...	168	112	300	...	500	...	...	...	11	1	11	5	19¼	1	13½	4¾	24·65
13	...	...	...	300	...	500	...	...	...	8	7	7	...		...		...	22·31
14	...	168	112	...	...	500	...	...	...	10	11	18	...		...		...	21·23
15	...	168	112	300	...	...	...	...	...	9	15	15	...		...		...	24·37
16	...	336	224	300	...	500	...	...	...	11	17	12	8	18½	1	13½	5¾	22·99
17	...	168	112	600	...	500	...	...	...	10	18	15	7	2½	2	14¼	7¼	24·69
18	...	168	112	300	...	1000	...	...	...	10	12	17	7	5	2	1½	6¾	24·71
19	...	168	112	300	...	...	206	...	...	10	3	25	6	6¾	2	7¼	6¾	23·28
20	...	168	112	300	...	...	...	800	...	9	18	16	6	4¼	1	15¾	10	21·09
21	...	...	...	...	...	500	...	...	1220	9	15	21	6	9¼	1	10	7½	23·70
22	...	168	112	...	560	500	...	...	...	8	16	23	...		...		...	21·20
23	12	...	...	...	...	...	...	...	...	9	5	33	7	0¾	1	5	4¾	...
24	12	84	56	150	...	250	...	...	...	9	11	19	...		...		...	...

NOTES.—The Artificial manures used for Plot 2 supplied 25 lbs. Nitrogen, 25 lbs. Phosphoric Acid, and 25 lbs. Potash per acre. The Sulphate of Potash was a "low class" manure but was practically free from Chlorides. The Fish Meal used on Plot 21 contained the same amount of Nitrogen and slightly more Phosphoric Acid than the corresponding Plot 16 received. The Dung applied to Plots 23 and 24 was made by sheep fed under cover and littered with peat moss. Plot 24 was interfered with by a tree.

TABLE XXVI.—EXPERIMENT ON THE MANURING OF SWEDES AND YELLOW TURNIPS IN EAST TOWER HILL, COCKLE PARK.

Plots.	Manuring per Acre.								Yield.			
	Dung.	Sulph. of Am.	Nitrate of Soda.	Super.	Slag.	Bone Meal.	Fish Meal.	Kainit.	Swedes.		Yellow Turnips.	
	Tons.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	T.	cwt.	T.	cwt.
1	18	...	...	...	...	...	...	...	24	11½	28	16
2	18	42	56	392	...	...	...	200	26	0¾	27	3¼
3	12	42	56	392	...	...	...	200	21	14¼	23	14¼
4	12	42	56	..	284	...	...	200	24	8½	27	12¾
5	12	21	28	...	...	210	...	200	23	7¾	27	3½
6	12	...	...	314	...	...	214	200	24	17¼	31	2¼
7	12	32	42	196	...	105	...	200	24	14¼	31	5¾
8	12	42	56	392	...	..	...	...	27	17¼	27	3½
9	12	...	...	392	...	..	...	200	22	12¾	23	10
10	12	...	...	...	...	...	...	...	20	0	22	7¼
11	...	...	...	...	...	...	...	...	7	17¼	11	17¾
12	...	42	56	392	...	...	...	200	17	4¼	25	10
13	...	84	112	784	...	...	...	400	22	11½	25	17¾
14	...	84	112	...	568	...	...	400	18	5	21	10
15	...	44	58	...	...	420	...	400	16	5	19	2¼
16	...	...	...	628	...	...	428	400	18	15¾	21	2¾
17	...	64	84	392	...	210	...	400	18	13½	20	2¾
18	...	..	110	784	...	...	...	...	12	4¼	19	10
19	...	...	...	784	...	...	...	400	19	1½	21	3½
20	...	...	56	...	...	...	...	200	17	17¼	20	15¾
21	...	..	...	...	...	...	...	...	7	1½	13	6½

NOTES.—The Artificial mixture for Plot 2 contained per acre 50 lbs. soluble Phosphoric Acid in about 3 cwt. high class Super., 25 lbs. Potash in about 2 cwt. Kainit, 17·5 lbs. Nitrogen in about ½ cwt. Nitrate of Soda and ⅜ cwt. Sulphate Ammonia.

TABLE XXVII.—FOURTH YEAR OF EXPERIMENT ON OLD LAND HAY IN P LEAS, COCKLE PARK. All Plots ½ Acre except Plots 17-20, which are ¼ Acre.

Plots.	Manuring per Acre.	Cost of Manures in 4 years.			Yield 1897.	Yield 1898.	Yield 1899.	Yield 1900.	Total yield in 4 years.	Increase in 4 years.	Net or l in 4
		£	s.	d.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.		£
1	8 tons Fold Manure and 3 cwt. mixed Artificials in each year	11	4	6	36½	44½	34¼	38¾	154	64¼	−3
2	8 tons Fold Manure each year; no Artificials	8	0	0	34½	40	32½	30¾	137¾	48	−2
3	8 tons Fold Manure each alternate year (1897, 99, etc.) with 3 cwt. Artificials in intervening years 1898, 1900, etc.)	5	12	3	31	41¾	29¾	33¼	135¾	46	0
4	8 tons Fold Manure each alternate year (1897, 99, etc.); no Artificials in intervening years	4	0	0	30½	33	29½	27½	12 ½	30¾	−0 3
5	16 tons Fold Manure every 4th year (1897, 1901, etc.) with 3 cwt. Artificials in intervening years (1898, 99, 1900, etc.)	5	12	3	31¼	44½	29½	30¾	136	46¼	0
6	Unmanured		...		22½	27½	19½	20¼	89¾	...	...
7	1¼ cwt. Sul. Am. each year	3	0	0	33½	37¼	25	26½	122¼	32½	1
8	3½ cwt. Super. (1898) or 3 cwt. Slag (1899) in alternate years	1	13	0	25	32¼	23¼	27	107½	17¾	0 1
9	1½ cwt. Sul. Potash each year	1	16	0	20	25½	13¾	16¾	76	−13¾	−3 1
10	1¼ cwt. Sul. Am. and 3½ cwt. Super. (1898) or 3 cwt. Slag (1899), each year	4	3	0	35¼	41½	26¼	30½	133½	43¾	1
11	1¼ cwt. Sul. Am. and 1½ cwt. Sul. Pot. each year	4	16	0	29¾	35¼	19	22¾	106¾	17	−2 1
12	3½ cwt. Super. (1898) or 3 cwt. Slag (1899), and 1½ cwt. Sul. Pot. each year	3	9	0	26¼	36¼	20½	26½	109½	9¾	−2
13	1¼ cwt. Sul. Am., 3½ cwt. Super. (1898). or 3 cwt. Slag (1899) and 1½ cwt. Sul. Pot. each year	6	9	0	33½	41	24¼	30½	129¼	39½	−1 1
14	⅜ cwt. Sul. Am., ⅞ cwt. Nit. Soda, 1¾ cwt. Super., 1½ cwt. Slag, and 1½ cwt. Sul. Pot. each year	6	9	0	34¾	43	27½	28¾	134	44¼	−0 1
15	Same as No. 14, but in alternate years only, (1897, 99, etc.)	3	4	6	30¾	29¼	21¾	17½	99¼	9½	−2
16	Half the dressing of No. 14 each year (same as Nos. 1, 3, 5)	3	4	6	25¼	36¼	18¾	22½	102¾	13	−1 1
17	8 tons Fold Manure in autumn of 1897-8, Artificials as Plot 16 in spring of 1900	4	16	3	...	45	20¾	30	95¾	28½	−1
18	8 tons Fold Manure in autumn of 1897 and 1898, and same Artificials as No. 16 in spring, nothing in 1900	5	12	6	...	54	24¾	26¾	105½	38¼	−0 17
19	8 tons Fold Manure in spring of 1898-9, and same Artifs. as 16 in spring of 1900	4	16	3	...	40	23¾	31¼	95	27¾	−1 7
20	8 tons Fold Manure in spring of 1898 and 1899, with same Artificials as No. 16 in spring, nothing in 1900	5	12	6	...	45¼	23½	25¼	94	26¾	−2 6
21	Turf ploughed, soil stirred, not rolled; dressed with the Artifs. of No. 14 for crops of 1898-9, and with Dung for 1900	5	4	6	...	34	24¼	29¾	88	10¾	−3 18
22	Turf ploughed, soil stirred, rolled; dressed with the Artificials of No. 14 for crops of 1898-9, and with Dung for 1900	5	4	6	...	37	23¼	30	90¼	23	−2 7
23	Turf ploughed, soil stirred, rolled; not manure for 1898-1899, Dung in 1900		...		...	22	15½	28½	66	−1¼	−0 3
24	Neither ploughed, stirred, nor rolled, but manured as Plot 21	5	4	6	...	50	24¾	30¾	105½	...	−0 8
25	Untreated in 1897-8-9; Dung in 1900		...		..	34½	16½	29¼	80¼	...	...
26	Turf ploughed, soil not stirred, but rolled and manured as Plot 21	5	4	6	...	39½	25	31¼	95¾	28¼	−1 5

Notes.—*Standard Dressings.* 30 lbs. Nitrogen per acre to Plot 7. 50 lbs. Phos. Acid per acre to Plot 8. 50 Potash to Plot 9. Plots 1-16 were started in 1897. Plots 17-26 in 1898. The same mixture of artificials is given to P 1, 3, 5, as to 16. Fold manure, when applied, was given to Plots 1-5 in the autumn. Plots 8, 10, 12, and 13 got Su for 1900. For the crop of 1900, Plots 21-26 got about 10 tons Dung per acre, and no other manure.

TABLE XXVIII.—COMPOSITION OF HAY FROM PALACE LEAS, COCKLE PARK, 1900.

	Plot 6.	Plot 7.	Plot 8.	Plot 9.	Plot 10.	Plot 11.	Plot 12.	Plot 13.
In samples on arrival:—								
Moisture at 100° C.	14·63	15·27	15·61	15·60	17·11	16·23	14·88	15·62
Calculated on sample dried at 100° C.—								
Amides	2·34	2·03	1·76	2·21	2·31	1·71	2·16	1·16
Albuminoids ...	6·40	6·30	6·91	6·47	8·29	6·66	8·56	9·14
Carbohydrates, etc. ...	51·82	52·64	46·03	48·04	46·80	50·48	48·38	40·58
Woody Fibre ...	31·16	30·92	34·85	32·32	31·80	32·02	29·58	37·97
Ash	8·28	8·11	10·45	10·96	10·80	9·13	11·32	11·14
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Total Nitrogen ...	1·40	1·33	1·39	1·39	1·70	1·34	1·72	1·65
Siliceous Matter ...	4·27	3·82	3·76	5·72	·32	4·79	3·85	3·84

TABLE XXIX.—COMPOSITION OF SOILS, COCKLE PARK FARM.

	12/5/98.						21/6/99.	14/5/00.	9/00.	14/5/00.	9/00.	14/5/00.	9/00.
	Miniature Farms.						Tree Field.	Hanging Leaves.		Castle Steads.		Davy Houses.	Long Riggs.
	No 147. Farm 1.	No. 148. Farm 2.	No. 149. Farm 3.	No. 150. Farm 4.	No. 151. Farm 5.	No. 152. Farm 6.	No. 194. Plot 6.	No. 265.	No. 275.	No. 267.	No. 276.	No. 266.	No. 277.
Soluble in Hydrochloric Acid.													
Ferric Oxide (Fe_2O_3)	...	...	...	...	...	...	...	4·89	...	2·77	...	3·10	...
Alumina (Al_2O_3)	...	...	...	...	...	...	...	5·52	...	3·51	...	4·01	...
Lime (CaO)	...	...	...	...	...	...	·69	·43	...	·25	...	·27	...
Magnesia (MgO)	...	...	...	...	...	...	...	...	...	...	...	...	...
Potash (K_2O)	·04	·04	·04	·05	·04	·05	·50*	·49	...	·31	...	·20	...
Soda (Na_2O)	...	...	...	...	...	...	...	...	...	...	...	...	...
Phosphoric Acid (P_2O_5)	·12	·11	·13	·13	·13	·12	·07	·06	...	·07	...	·08	...
Soluble in Citric Acid.													
Potash (K_2O)	·010	·013	·013	·013	·012	·010	·013	·010	·017	·017	·012	·018	·010
Phosphoric Acid (P_2O_5)... ...	·039	·033	·035	·024	·022	·020	·005	·007	·008	·008	·009	·013	·002
Nitrogen (N) Total	·15	·15	·15	·15	·15	·15	·20	·18	...	·16	...	·23	...
Carbonic Acid (CO_2) combined	...	...	...	...	...	...	...	...	...	...	...	...	...
Organic Matter and Water of Combination	...	...	...	...	...	...	9·31	9·63	...	8·40	...	9·94	...
Silica and Silicates insoluble in Hydrochloric Acid (HCl)	...	...	...	...	...	...	76·21	79·69	...	83·20	...	82·65	...
Stones over 3 mm.	...	...	...	...	...	...	...	...	...	2	...	...	...
Coarse Sand 3 – ·5 mm. ...	...	...	...	...	...	...	1	2	...	24	...	8	...
Medium ,, ·5 – ·25 mm. ...	...	...	...	...	...	...	2	10	...	35	...	34	...
Fine ,, ·25 – ·1 mm. ...	...	...	...	...	...	...	4	7	...	11	...	10	...

* Soil ignited and digested 6 hours.

TABLE XXX.—WEIGHT OF SOIL. PLOT 6, TREE FIELD, COCKLE PARK. JANUARY 24TH, 1900.

	217 East.	218 Middle.	219 West.	Mean.
	Lbs.	Lbs.	Lbs.	Lbs.
cubic foot, wet	109	112	120	
„ „ dried, at 100° C.	84	87	87·4	86·1
Water %	22·94	22·31	27·20	—

TABLE XXXI.—COMPOSITION OF SOILS.

These Analyses were made by Mr. Greig Smith, M.Sc., and have not been published in full. They are reckoned on the Fine Soil dried at 100° C.

	4/11/94.	1896.				20/5/97.	
	College Garden.	Whitefield.		Peepy.		Grange Hill.	
	No. 51.	No. 78. Soil.	No. 79. Sub-soil.	No. 80. Soil.	No. 81. Sub-soil.	No. 116. Soil.	No. 117 Sub-soil.
Ferric Oxide (Fe_2O_3) Sol. in Hydrochloric Acid Alumina (Al_2O_3), Sol. in Hydrochloric Acid	6·14	...	...	...	...	...	...
Lime (CaO) Sol in Hydrochloric Acid	1·41	...	...	...	...	...	...
Magnesia (MgO) Sol. in Hydrochloric Acid	...	...	...	...	...	...	...
Potash (K_2O) Sol. in Hydrochloric Acid	...	·07	·03	·14	·12	·07	·08
Phosphoric Acid (P_2O_5) Sol in Hydrochloric Acid	...	·12	·06	·03	·01	·13	·08
Potash (K_2O) sol. in Citric Acid	...	·010	·005	·015	·011	·008	·020
Phosphoric Acid (P_2O_5) Sol. in Citric Acid	...	·012	·006	·018	·002	·009	·005
Nitrogen (N) Total ...	·36	·16	·07	·17	·05	·14	·11
Organic Matter and Water of Combination	19·81	...	...	...	...	...	...
Silica and Silicates insoluble in Hydrochloric Acid	71·63	...	...	...	...	...	...
Stones over 3 m.m.... ...	31½	19½	39½	4½	11½	9	8
Coarse Sand 3 to ·5 m.m. ...	9	8½	12¼	5	6	4	2

	Rotted, October, 1897.	Fresh, October 25th, 1898.	Rotted, April 28th and May 8th, 1899.	Fresh, Amount on October 25th, 1898.	Rotted, Amount remaining in April-May, 1899.	Loss – Gain+	Fresh, Feb. 14, 1900.	Rotted, May 31, 1900.	Fresh, Amount on Feb. 14, 1900.	Rotted. Amount remaining May 31, 1900.	Loss – Gain+	Average of 2 yrs. Loss – Gain+
		Per Cent.	Per Cent.	Lbs.	Lbs.	Per Cent.	Per Cent.	Per Cent.	Lbs.	Lbs.	Per Cent.	Per Cent.
Water	72·75	74·19	78·36	...	..	...	82·06	82·18	...	...		...
Organic Matter	...	21·09	16·86	4,252	3,329	– 22	14·73	13·38	998	797	– 20	– 21
Mineral Matter	...	4·72	4·78	951	944	– 1	3·21	4·44	218	266	+ 22	
Total	...	100·00	100·00	20,160	19,747	...	100 00	100·00	6812	5978	..	...
Nitrogen as Nitrates ..	None.	None.	None.	...	...	...	None.	None.	...	...	...	...
„ Ammonia ...	·15	·276	·143	...	...	...	·205	·124	...	...	...	...
„ Amides ...	·09	·100	·057	...	...	...	·072	·086	...	...	...	...
„ Albuminoids	·51	·431	·439	87	86	– 1	·289	·255	20	15	– 25	
Total Nitrogen ..	·75	·807	·639	163	126	– 23	·566	·465	38	27	– 29	– 26
Phosphoric Acid, Soluble	·06	·131	·183	...	...	...	·095	·154	...	...	...	...
„ „ Insoluble	·21	·144	·143	...	. .	...	·203	099	...	...	...	...
Total Phosphoric Acid	·27	·275	·326	55	64	+ 16	·298	·253	20	15	– 25	...
Potash, Soluble	·56	·548	·434	...	...	...	·467	·493	...	...	...	...
„ Insoluble... ...	·12	·087	·131	...	...	...	·206	·038	...	...	...	...
Total Potash	·68	·635	·565	128	112	12	·673	·531	46	32	– 30	– 22
Lime	...	·337	·386	68	76	+ 12	·271	·283	18	17	– 5	...
Insoluble Silicates ...	...	2·53	2·83	510	558	+ 9	1·30	2·50	88	149	+ 69	...
Mineral matter, soluble ...	...	2·19	1·95	441	386	– 12	1·91	1·94	130	115	– 12	– 12

TABLE XXXIII.—COMPOSITION OF MANURES FOR COCKLE PARK.

	No. 241. 6/3/1900. Superphosphate, 34 %	No. 242. 6/3/1900. Dissolved Bones.	No. 248. 14/3/1900. Precipitated Bone Phosphate.	No. 308. 6/12/1900. Basic Slag.
Soluble Phosphoric Acid (P_2O_5)	16·70	11·40	...	...
= Calcium Phosphate ($Ca_3P_2O_8$)	36·45	24·88	...	...
Insoluble Phosphoric Acid (P_2O_5)	1·06	5·30	36·35	...
= Calcium Phosphate ($Ca_3P_2O_8$)	2·32	11·56	79·34	37·21
Nitrogen	...	2·81	...	...
= Ammonia ...	...	3·41	...	...
Fineness	...	...	...	80

TABLE XXXIV.—COMPOSITION OF MANURES FOR COCKLE PARK.

	No. 243. 6/3/00. Kainit.	No. 257. 24/4/00. Kainit.	No. 249. 26/3/00. Sulphate of Potash.	No. 258. 24/4/00. Sulphate of Ammonia.	No. 335. 10/12/00. Lime from Fourstones	No. 336. 10/12/00. Lime from Little Mill.
Potash (K_2O)	11·81	12·63	9·92	...	...	...
= K_2SO_4	...	...	18·36		...	...
Nitrogen	...	...	...	20·57	...	...
= Ammonia ...	...	..	...	24·98	...	...
Lime (CaO)	...	...	...	...	89·28	73·30
Salt	61·01	52·90	...	...	...	...

TABLE XXXV.—COMPOSITION OF MANURES USED IN EXPERIMENTS IN THE COUNTIES OF CUMBERLAND, DURHAM, AND NORTHUMBERLAND.

Ref. No.	Date.	Manures.	Calcium Phosphate ($Ca_3P_2O_8$.) Sol.	Calcium Phosphate ($Ca_3P_2O_8$.) Insol.	Potash (K_2O.)	Nitrogen. (N.)	Ammonia. (NH_3.)	Salt. (Na Cl.)	Purity.
			%	%	%	%	%	%	%
184	28/3/99	Nitrate of Soda	...	...	...	15·77	19·15	...	95·76
408	8/2/01	,, ,, ,,	...	...	...	16·03	19·47	...	97·33
182	28/3/99	Sulphate of Ammonia	...	...	...	20·73	25·20	...	97·75
252	2/4/00	,, ,, ,,	...	...	...	20·54	24·94	...	96·87
264	4/5/00	Fish Meal	...	12·95	...	8·20	9·96	...	...
183	28/3/99	Dissolved Bones	21·93	11·35	...	2·68	3·25	...	...
175	9/2/99	Superphosphate 34 %	34·70	2·77	...	...	...	...	...
251	27/3/00	,, 25-27 %	27·95	2·14	...	...	...	..	...
253	5/4/00	,, 25-27 %	26·87	1·87	...	..	...	...	...
170	18/11/98	Basic Slag	...	37·26	...	...	..	...	...
171	18/11/98	,, ,,	...	36·46	...	...	...	...	...
172	18/11/98	,, ,,	...	36·67	...	...	...	...	...
410	19/2/01	Precipitated Bone Phosphate	...	79·40	...	...	..	...	...
179	8/3/99	Kainit	...	...	12·25	...	...	...	...
191	5/5/99	,,	...	...	11·80	...	...	...	...
232	20/2/00	,,	...	...	11·16	...	...	...	...
250	27/3/00	,,	...	...	12·37	...	...	...	...
254	5/4/00	,,	...	...	12·39	...	...	62·46	...
407	7/2/01	,,	...	...	12·40	...	...	60·13	...
181	28/3/99	Sulphate of Potash	...	...	31·66	...	...	...	58·73
255	24/4/00	,, ,, ,,	...	...	30·63	...	...	...	56·69
256	24/4/00	Muriate ,, ,,	...	...	48·53	...	...	...	76·95

TABLE XXXVI.—COMPOSITION OF FEEDING STUFFS FOR COCKLE PARK, JANUARY 23RD, 1900.

	No. 233. Linseed Cake.	No. 234. Decorticated Cotton Cake.	No. 235. Cotton Seed Meal.
	£8 Per Ton.	£7 Per Ton.	£6 7s. 6d. Per Ton.
Moisture	10·73	7·77	8·59
Oil	7·02	10·37	12·53
Albuminoids	35·62	43·50	43·12
Carbohydrates, etc.	34·74	24·41	23·76
Woody fibre	7·38	6·83	5·60
Ash	4·51	7·12	6·40
	100·00	100·00	100·00
Nitrogen	5·70	6·96	6·90
Sand	...	...	...

TABLE XXXVII.—NO. 305, COMPOSITION OF MOLASSINE—A CATTLE FOOD, 14/11/1900.

Moisture	31·36
Oil	·55
Albuminoids	1·25
Nitrogenous Extractives ...	5·08
*Sugars (as Glucose)	34·99
Undetermined	12·75
Woody fibre	6·01
Ash	8·01
	100·00

* Principally Cane Sugar.

TABLE XXXVIII..—COMPOSITION OF BUTTER, COLLEGE DAIRY, 27/2/1900

These Analyses were made for the purpose of ascertaining how the composition of butter is affected by the size of the grain, and the temperature of the water used in washing.

Reference No.	Size of Grain.	Temperature of Washing-Water.	Percentage Composition.		
			Water.	Butter Fat.	Curd, Ash, and Salt.
240	Proper size	Correct, 48° F.	10·55	87·92	1·53
236	Too large	High, 65° F.	13·05	85·95	1·00
237	Too small	Do., do.	12·50	86·49	1·01
238	Too large	Low, 35° F.	11·19	87·49	1·32
239	Too small	Do., do.	11·21	87·29	1·50

Temperature of Cream before churning, 60° F.
Temperature of Dairy during churning 52° F.
High Temperature has increased the water by about 2%.
Large Grain has increased the water by about ½ %.

The Durham College of Science,

NEWCASTLE-UPON-TYNE.

PRINCIPAL, HENRY PALIN GURNEY, M.A., D.C.L.

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This list comprises the names of Teachers whose classes are attended by Agricultural Students. A complete List of the Professors and Lecturers will be found in the College Calendar.

COUNTY COUNCILS OF CUMBERLAND, DURHAM,
AND NORTHUMBERLAND.

TECHNICAL EDUCATION.

PERIMENTS WITH CROPS AND STOCK

CONDUCTED BY

THE AGRICULTURAL DEPARTMENT,

OF THE

ham College of Science, Newcastle-upon-Tyne.

DURING SEASON 1901.

Tenth Annual Report,

COMPILED BY

T. H. MIDDLETON, M.A., M.Sc.,

Professor of Agriculture and Rural Economy

LONDON AND NEWCASTLE-UPON-TYNE:
ANDREW REID AND COMPANY, LIMITED, PRINTERS AND PUBLISHERS.

1902.

PREFACE.

The experiments described in this Report have been carried out (*a*) at local stations in the three Northern Counties, which have been placed at the disposal of the College by their owners, or occupiers; (*b*) at the Cumberland County Farm School, Newton Rigg, Penrith.

In former Reports an account of the experiments conducted at Cockle Park, the Northumberland County Demonstration Farm, was included. The work there has so much increased that it has been decided to report upon it separately. The Report on the Cockle Park experiments will in future be issued by the Technical Education Committee of the County and not by the College of Science.

The local experiments are of two kinds, viz.:—Those which continue for a series of years—Rotation and Meadow Hay Experiments—and those which last for a single season—on swedes, turnips, mangels, potatoes and seeds hay. The latter are largely arranged in connection with the extension lectures delivered by Mr. Greig. In those districts which have not been previously visited, experiments on swedes or turnips are laid down with the object of ascertaining the manurial requirements of the soil for these crops. In districts which have already been tested, experiments on other farm crops are arranged. The manurial condition (in Durham especially) is very variable, and the intention is to map out the different agricultural tracts in the northern counties and to establish permanent Rotation and Hay Stations in each.

The manures for these experiments are all sent out from the College and delivered free of cost to the farmer who provides the land. Members of the Agricultural Staff measure off the plots, attend when necessary to see the manures applied, inspect the growing crop, and in almost all cases see the produ weighed. Mr. Lawrence of Newton Rigg co-operates with th College representatives in the case of stations located i Cumberland, and for the experiments at Newton Rigg, M Lawrence is entirely responsible.

The chemical analyses which the experiments involve a made in the College Laboratory by Mr. Collins.

During season 1901, the field experiments with whic members of the College Agricultural Staff were directly con cerned numbered 47, distributed as follows:—

	Number of Centres.	Number of Plots.	Area of land under experime Acres.
Rotation and Meadow Hay Stations...	16	276	32
Temporary Local Stations	31	510	21
	47	786	53

In addition to the foregoing five new meadow hay station were laid out in County Durham, and the work at the North umberland County Farm of 400 acres was carried on, as befor under the supervision of the Department.

Nearly all the stations were visited by myself, many of th more than once, and when, for any reason, the results of th experiments were likely to mislead, the figures relating to th have been excluded from the "averages" or have been omitt In the Preface to last year's Report, it was said that "the con ditions under which field experiments are carried out make impossible that the results should be uniform, but each resu correctly represents the effect of certain conditions, and is value if rightly interpreted."

In drawing conclusions from the experiments of 1901, have as far as possible, attempted to interpret the results i the light of the information obtained when visiting the plots.

The Appendix contains tables giving detailed figures f the experiments reported on. The quantities of manure a stated in "cwt. per acre." These figures are only approximate as almost every purchase of manure varies in quality. Manur are not applied by the hundredweight, but in the case of eac experiment a "standard dressing" supplying a certain number of pounds of nitrogen, phosphoric acid or potash, is fixed upon, and as much of the manure (nitrate of soda, superphosphate, kainit, etc.) as contains the "standard" quantity is employed. The "standard dressing" as given to one or other of the plots is stated in the table containing the results of each experiment. The tables of the Appendix are numbered I., II., etc. The summary tables in the text A, B, etc.

In the case of permanent experiments, it is undesirable to re-calculate the cost of the manures each season and the prices have been allowed to stand at the figures used in former Reports; in the case of the temporary experiments the prices of the spring of 1901 have been used. The prices are those at which 2-ton lots could have been purchased within 20 miles of Newcastle, the prices are in round figures and include a small allowance for cartage.

The percentages given indicate the quality of the manure upon which the price has been based; the actual composition varied in different cases. (See p. 115.)

MANURE.	For Permanent Experiments. Per Ton.	For Temporary Experiments. Per Ton.
Nitrate of Soda (15·5 % Nitrogen)	£9 0 0	£9 0 0
Sulphate of Ammonia (20·6 % Nitrogen)... ...	12 0 0	10 15 0
Superphosphate (28 % Soluble Phosphate) ...	3 0 0	3 0 0
Basic Slag (37 % Insoluble Phosphate)	2 5 0	2 5 0
Bone Meal (52 % Insoluble Phosphate and 3½ % Nitrogen)...	5 10 0	5 10 0
Dissolved Bones (22 % Soluble Phosphate, 12 % Insoluble Phosphate, and 2½ % Nitrogen) ...	5 0 0	5 0 0
Precipitated Bone Phosphate (79·40 % Insoluble Phosphate)	—	5 5 0
Fish Meal (11 % Phosphate and 8 % Nitrogen) ..	6 10 0	6 10 0
Muriate of Potash (50 % Potash)	9 10 0	9 10 0
Sulphate of Potash (30 % Potash)	5 10 0	5 10 0
Kainit (12 % Potash)	2 5 0	2 5 0

T. H. MIDDLETON.

The University, Cambridge,
May, 1902.

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SEASON 1901.

In studying the action of manures and in attempting to draw practical lessons from manurial experiments the character of the season in which the experiments were carried out must always be carefully taken into account. In the following pages frequent references are made to the effects of the weather as influencing the results obtained in 1900 and 1901.

The dry hot summer of 1901 was a marked contrast to its predecessor, and a comparison of the results of the two seasons is unusually instructive.

Table I. of the Appendix gives the rainfall and hours of sunshine for every fortnight in the two years, at Cockle Park, and from it we learn that in east Northumberland we had 3 inches less rain and 334 hours more sunshine during the growing season (April 1st to September 30th) of 1901, than we had in 1900.

The following were the differences in rainfall and sunshine during each quarter of the past two seasons:—

	Rainfall.	Sunshine.
	Inches.	Hours.
1st quarter 1901±1900 ...	−5·466	− 15·0
2nd do. do.	−1·050	+226·7
3rd do. do.	−1·934	+107·3
4th do. do.	− ·647	+ 66·6
Year 1901±1900	−9·097	+385·6

I.

EXPERIMENTS ON THE MANURING OF SWEDES AND TURNIPS (TABLE II.).

In continuation of the experiments made last year, experiments were carried out on these root crops at twelve centres in the county of Durham and one in the county of Northumberland in the summer of 1901. The names of the centres, the character of the soils, the names of the varieties grown and other particulars are given in Table A.

TABLE A.

No.	Farm.	Occupier.	Remarks.
1	Cleatlam, Staindrop.	Mr. Chandler.	Best of all Swede (Tait) on gravelly loam.
2	Neasham Grange, Darlington.	Mr. Humphrey.	Best of all Swede (Tait) on rich alluvial soil.
3	Newlands Haugh, Ebchester.	Messrs. The Derwent Flour Co. (farm manager, Mr. Hamilton).	Best of all Swede (Tait) on loam after oats after lea (2 years grazed and 2 years hay).
4	West Farm, Medomsley.	Mr. Bell.	Purple Top Swede on gravelly loam after oats.
5	East Farm, Medomsley.	Mr. G. Bell.	Green Top Swede on gravelly soil after lea oats.
6	Springs House, Birtley.	Mr. H. G. Fenwick.	Best of all Swede. Light soil in high condition.
7	Sands Hall, Sedgefield.	Mr. R. Ord.	Giant King Swede (Webb) on gravelly loam after wheat following potatoes.
8	Glower o'er 'em, Sedgefield.	Mr. Shepherd.	Imperial Swede (Webb) on light loam soil.
9	Howley Hope, Sedgefield.	Mr. Robinson.	Kangaroo Swede. Light sandy soil.
10	Sherburn Colliery.	Mr. Wearmouth.	Arctic Swede. Light thin soil on Magnesian limestone.
11	Snotterton Hall.	Mr. Thompson.	Best of all Swede on clay loam after oats.
12	Usworth.	Mr. W. Maclaren.	Swedes on clay loam. Crop failed from "finger-and-toe."
13	High Bradley, Medomsley.	Mr. Simpson.	Aberdeen Green Top Yellow Turnips. Sandy loam.

Objects.—

The objects of these experiments were:—

(1) To test the soil of certain districts.

(2) To compare superphosphate, slag and precipitated bone phosphate as manures for roots.

(3) To ascertain the effects of using certain mixtures of artificial manures along with dung.

(4) To test the effects of certain of the manures on the quality of the crop.

The last of these—the effects of manures on quality—is discussed at pp. 104 to 108, the others will be referred to here.

On two of the thirteen farms the crop was so uneven that it was not weighed. In one case the injury was due to finger-and-toe, in the other, the soil, a rich clay loam, was in poor tilth when sown and the crop did not braird evenly. The crop was weighed at eleven centres and the weights will be found in full in Table II. At four of the centres slight irregularities in the soil interfered with the comparative character of the tests and the figures from these stations have not been included in the average returns upon which the calculations of profit have been based. Most of the plots on these four stations gave consistent returns and though excluded from the averages the figures will in certain cases be referred to below.

Testing the Soil.—

The soil test was carried out in the same way as last season. One plot received no manure, a second a complete manure,* and from a third, fourth and fifth, nitrogen, phosphates and potash were in turn omitted.

---

* A manure supplying nitrogen, phosphates and potash is termed a complete manure, though not strictly *complete.* The particular manure here used supplied 35 lbs. nitrogen, 100 lbs. phos. acid and 50 lbs. potash per acre. The percentage composition was nitrogen 2·8 %, (= ammonia 3·4 %), phos. acid 8 % (= tribasic phosphate of lime 17·4 %), potash, 4 %.

In this way each farm indicates which constituent of a mixed manure is most important in producing a crop of roots, and the condition of the soil with respect to available plant food can be ascertained with considerable accuracy.

The results of the test on the average of seven farms is given in Table B. The results for each farm will be found in Table II. p. 127.

TABLE B.

Plot.	Per Acre.				
	Manuring.	Cost of Manure.	Average Yield.	Increase due to Manure.	Profit due to manure.
		s. d.	T. cwt.	T. cwt.	s. d.
8	**No manure**	—	11 5	—	—
2	1 cwt. nitrate of soda, ¾ cwt. sulphate of ammonia, 7 cwt. super., 4 cwt. kainit (**complete manure**)	42 6	20 11¼	9 6¼	32 0
5	Same as Plot 2, but no **nitrogen** ...	25 6	18 3	6 18	29 6
6	Do. no **phosphates**	25 0	15 5½	4 0½	7 0
7	Do. no **potash** ...	34 3	18 15½	7 10½	26 9

The general results of 1901 agree with those of 1900 (compare Ninth Annual Report, page 11). On the average, phosphates have been most necessary and potash least required in both seasons. Although the relative position of the plots remains unchanged there is a striking difference in certain of the figures obtained in the two seasons. These differences are shown below.

Crops grown with:	1900. T. C.	1901. T. C.
No manure	6 0	11 5
Manure without phosphates ...	7 10¼	15 5½
Complete manure	18 2	20 11¼

These figures show that in 1901 the conditions were distinctly better for root growing than in 1900, and that the absence of a phosphatic manure was less keenly felt by the crop. The higher returns from both the unmanured and the partially manured plots, though chiefly due to the soils experimented on, appear to have been partially due to the warm and dry summer of 1901. It was observed that some of the plots which exhibited marked phosphate-hunger up to the end of July made a wonderful recovery in the autumn months; at Newlands Haugh, for example, Plots 6 and 8 were very poor and backward at first but they ultimately produced 22 to 23 tons of swedes per acre. No such recovery was noticed in 1900, and it seems probable that a dry season, too dry for land properly treated, may be relatively favourable for unmanured root crops or for root crops not sufficiently supplied with soluble phosphates. When June and July are moist, growth is more rapid, plant food is more dilute and a badly fed crop may then suffer more than if it were growing slowly in a dry soil.

Apart from the question of season, however, it will be seen by reference to the details in Table II. that the soils experimented on in 1901 have been naturally richer in phosphates than those tested in 1900. Omitting phosphates practically destroyed the crop on 5 out of 13 farms tested in 1900, whereas in 1901 it has proved disastrous on one farm only (Cleatlam) out of 11. In 1900 phosphates proved to be the most necessary on 9 of the 13 farms tested. In 1901 the position taken by each constituent of the manure is shown below.

	No. of times most necessary of the three.	No. of times least necessary of the three.
Nitrogen	3	6
Phosphates	4	1
Potash	4	4

It has already been shown in Table B above that, in the case of the seven farms where the conditions were most favourable for experiment, the total effect produced by omitting phosphates was much more pronounced than that due to the absence of nitrogen and potash; but while this result enables us to enforce what has so often been said before, viz., that for the root crop most soils demand a liberal use of phosphatic manures, it also enables us to repeat what was said last season about the necessity for testing each soil and suiting the manure to the special requirements of the farm. The mixture used on Plot 2 has proved, as last year, to be a good *average* artificial manure, but it has again been shown that this good average manure is not likely to be the best for each, if indeed for any, of the individual farms among those tested.

It was remarked on page 13 of last year's Report that the two farms where nitrogen-hunger was most marked were situated within four miles of each other in the Ferryhill district. It is interesting to notice that the two farms showing the greatest need for nitrogen in 1901 also belonged to this district, being situated within a mile of the village of Sedgefield. The light gravelly soils of this part of the county appear to be relatively well provided with both phosphates and potash, but to stand in need of nitrogenous manures. In 1900 all the clay and loamy soils overlying the Magnesian Limestone were found to be extremely deficient in phosphates. This season only one soil on the limestone was tested, it was a thin gravelly loam close to the rock itself and not lying on drift, this particular soil proved to be well supplied with phosphates, but both its position and agricultural history were exceptional and it cannot be regarded as typical of the district (Sherburn) in which it was situated.

The soils of the high-lying and undulating country round Medomsley were found to vary very much. On the whole phosphate-hunger was their chief characteristic. The necessity for phosphates was more marked to the east of Medomsley towards Leadgate than to the west.

The crop was weighed at two only of the three stations in the valley of the Tees, viz., at Cleatlam and at Neasham Grange. In both cases, as at Piercebridge in 1900, phosphatic manures were found to be most required.

In connection with the results of the soil tests published the Report for 1900 (see Table I. p. 188) and in this eport (see p. 127), the following hints may be found useful.

When the swede crop succeeds fairly well without a phos-hatic manure, it is not likely that this class of manure will ay on corn crops and seeds hay. When on the other hand he absence of phosphates seriously reduces the yield of the swede crop as at Cleatlam, it will usually be found profitable o dress the seeds with slag in autumn, or superphosphate n spring and the corn crops with superphosphate at seed ime. When the absence of a nitrogenous manure seriously educes the root crop, as at Sands Hall, the crops generally re likely to respond to the free use of concentrated feeding tuffs, or to the use of fish meal or sulphate of ammonia and nitrate of soda.

When the root crop suffers from the absence of potash manures, as at Howley Hope, then sulphate or muriate of potash should be freely used for potatoes and mangels, and clover may also be improved by the use of these manures, or of kainit, in autumn or early spring.

Small v. Large Dressings of Artificials.—

In both the wet season of 1900 and the dry season of 1901 a light dressing of artificial manures costing 21s. per acre proved slightly more profitable than twice the quantity. (For the composition of the manure see Table B, Plot 2.) The yields were:—

	6⅜ cwt. manure.		12¾ cwt. manure.	
	T.	C.	T.	C.
1900	15	4½	18	2
1901	18	0¾	20	11¼

The application of 6⅜ cwt. of manure has raised the average produce, as compared with the unmanured plot, by 8 tons, a further application of 6⅜ cwt. has increased the crop by 2 tons 14 cwt. only. From these figures it may be inferred that for growing swedes without farmyard manure a dressing of about 10 cwt. mixed artificials, costing 32s. to 36s. per acre, should, on the average, be sufficient.

Phosphates from Different Sources.—

In season 1900 insoluble phosphate of lime in the form of basic slag proved to be a perfect substitute for the more expensive soluble phosphate of superphosphate in the case of 6 farms out of 10 on which the crops were weighed, and as the mixture containing slag was much cheaper than the other, there was an average profit of 5s. 2d. per acre in favou of slag over all 10 farms.

In season 1901 insoluble phosphate of lime in slag, and also in precipitated bone phosphate, was again tested under very different conditions as regards season. The average results obtained from seven stations are shown in Table C below.

TABLE C.

Plot.		Cost of mixture.		Average crop on seven stations.		Profit from manure.	
		s.	d.	T.	C.	s.	d.
2	Mixture containing **superphosphate**	42	6	20	11¼	32	0
3	Do. **slag**	36	6	18	4	19	0
4	Do. **precipitated bone phosphate**	37	9	19	14½	30	3
8	No manure	—		11	5	—	

On the average of these seven stations (see Table II. for details) superphosphate proved most profitable in the dry summer of 1901, the cheaper mixture, containing precipitated phosphate, gave results which were nearly as good, but slag was a bad third.

Analysing the results on all of the eleven farms we find that—

Superphosphate occupied the first place	7	times and the last place			2	times.
Precipitated bone phosphate	„	4	„	„	„ 2	„
Basic slag	„	1	„	„	„ 7	„

At one of the centres (Neasham Grange) superphosphate and precipitated phosphate were exactly equal and have both been credited with a first place.

It was to be expected that in a season so favourable to a soluble manure and on soils which, in the main, were light, superphosphate would take first place; the surprising thing is that the insoluble phosphates have done so well as they have done. The rapidity with which slag acted upon the young crop in the early part of June, was specially remarked upon by some of the experimenters, and our experiences in the past two seasons show that in the case of the average farm of this district there is a good deal to be said for insoluble phosphates as turnip manures. On most soils free from sourness, supplied with lime and not liable to finger-and-toe, superphosphate will give the heaviest crop, but on heavy damp soils slag is likely to prove both cheapest and best; and for light soils deficient in lime and liable to finger-and-toe, precipitated bone phosphate, steamed bone flour or phosphatic guanos may be recommended. The farmer who wishes to know which of these phosphates suits his land best should test them in mixtures like those given in Table II. Those who do not wish to experiment may be advised to blend their manures thoroughly (in the soil *not* in the sack*).

Farmyard Manure v. Artificials.—

Throughout the autumn the roots on the plots which had received 12 tons farmyard manure looked better than where artificials only had been employed and it was anticipated that after the very dry season the home manure would produce a greater weight of roots, but an appeal to the weighbridge proved that at 7 out of 11 centres Plot 2 produced a better crop than Plot 10. In the wet season of 1900 the results were quite similar, at 8 out of 10 stations an artificial mixture proved superior to 12 tons of dung. It seems safe to conclude therefore that in most instances a farmer whose supply of farmyard manure is insufficient, may depend on getting as good a crop of swedes from the 10 cwt. mixture referred to above as from 18 loads of farmyard manure. If the roots are carted off, the after effects of the light manure will of course be much less satisfactory, and it is for this reason, rather than on account of the root crop itself that the use of dung for roots is to be recommended. Our experience has always been more favourable to artificials than common report would lead one to anticipate. The unfavourable views so often expressed must be received with caution, adverse opinions have, in many cases, been arrived at as the result of using unsuitable mixtures, and "light manures" have been condemned when the fault was really the farmer's.

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* Slag or precipitated bone phosphate or nitrate of soda, should not be mixed with superphosphate. Sulphate of ammonia or kainit should not be mixed with slag.

The Use of Artificials with Dung.—

As Dr. Somerville pointed out some years ago, it is seldom that artificial manures prove directly profitable when used with 12 tons of dung for growing swedes. At the same time our experience in most of our rotation experiments shows that when the effects of the supplementary manure on the subsequent crops is taken into account, a handsome profit may be realized by all who use artificials judiciously.

Further it has been shown that in the north of England it is desirable to apply phosphates and probably also potash manures (where these are required) with dung for the root crop rather than directly to the corn and hay crops. Even if phosphates and potash are not paid for by the increased root crop we are justified in using them with dung.

But how about nitrogenous manures? Theoretically they should not be necessary for the root crop where farmyard dung has been freely used, and so far as the subsequent crops are concerned it is certainly best to apply such soluble manures as nitrate of soda and sulphate of ammonia direct to those that require nitrogenous dressings. We might, therefore, conclude that they should be left out of a mixture of artificials intended for use on roots with dung. Our experience, however, does not warrant this theoretical conclusion, and we find that a mixture of artificials to be applied with moderately rotted dung for roots should contain from ½ to 1 cwt. per acre of sulphate of ammonia, or of a mixture of sulphate of ammonia and nitrate of soda.

Some of the figures on which this opinion is based will be found in Table D, which shows the effects produced by the use of various artificial mixtures with dung in the case of seven of last year's centres.

TABLE D.

Plot.	Treatment per acre.	Cost of manure.	Yield per acre.	Profit over Plot 8. Roots 8s. per ton.	Increase over Plot 10.	
					Amount of.	Cost of roots per ton.
		s. d.	T. C.	s. d.	T. C.	s. d.
8	No manure	—	11 5	—	—	—
10	12 tons farmyard manure... ...	30 0	19 8	35 0	—	—
11	Do. with **complete** artificial mixture.*	51 3	20 18	25 0	1 10	14 0
12	Do. **nitrogen omitted** from artificials.	42 9	19 18	26 3	0 10	25 6
13	Do. **phosphates** do. do.	42 6	20 11½	32 0	1 3½	10 8
14	Do. **potash** do. do.	47 3	21 2½	31 9	1 14½	10 0
15	Do. **nitrogen and potash omitted** from artificials	38 9	19 13½	28 9	0 5½	31 10

* The mixture consisted of ½ cwt. nitrate, ¾ cwt. sulphate of ammonia, 3½ cwt. superphosphate, and 2 cwt. kainit per acre.

The above table shows that where roots are valued at 8s. per ton the greatest profit has on the average been made from farmyard manure used by itself. The last column of the table indicates the cost per ton of producing additional roots by the aid of artificials. In comparing the effects of the manures it should be noted that dung has been charged f at the rate of 2s. 6d. per ton (not more than half its value o farms situated beyond the reach of “ town manure ”), and th artificials have been charged at their full market pric When the residual value of the artificial manure used on Pl 11 is taken into account, the resulting increase of crop wi be admitted to be satisfactory. The omission of phosphat or of potash from the artificial mixture has not serious affected the crop. The latter indeed has scarcely affect the average results at all. At the majority of the farm Plots 11 and 14 were practically alike, and the slight better crop on the latter was due to an inequality in the so at Neasham Grange. Last season, chiefly owing to the result obtained from one of the farms (Earls House), the crop wa reduced by 18 cwt. by leaving out potash. In neither season has the addition of 2 cwt. of kainit to an artificial mixture, for use with 12 tons of dung, much affected the root crop. But as the cost of this application is only 4s. 6d. per acre, and as the omission of potash at this stage might injuriously affect the young seeds, and possibly also the barley crop on some classes of land, it is safe to include kainit in the mixture until it can be proved that it is unnecessary. The omission of phosphates has reduced the crop of roots by a few cwt. only and it has cheapened the cost of producing a ton of produce from 14s. to 10s. 8d., but most men who attempt to save the cost of a phosphatic manure when laying down the green crop, will have cause to regret their action before the end of the rotation.

General experience and our own experience in conducting rotation experiments agree that, in spite of the poor return which we usually get from the root crop for the phosphatic and potash manures employed with dung, the application of these manures is justified by their results on the subsequent crops. But the justification for the use of sulphate of ammonia and nitrate of soda must come from the root crop elf and if there is no direct return they ought to be mitted. Our experience, as has already been said, is that in e majority of cases there is a direct return. On the average f seven farms last season 8s. 6d. worth of manure produced e ton of roots and if Neasham Grange were excluded the turn would have been a good deal higher. On 8 out of 11 rms mentioned in Table II. the nitrogenous manure increased e crop; in four cases very profitably, and in two more the eturns were fair, nearly a ton per acre. In the wet summer f 1900 the effects of the nitrogenous dressings were much ore favourable than in 1901. An outlay of 9s. worth of anure produced an average return (on 8 farms) of over 2 ons of swedes, that is to say, on 8 farms out of 11 on which the crop was weighed, the increase was very profitable.

Practically the same result was obtained in the series of trials made by Dr. Somerville on 20 farms in the three northern counties in 1894 and 1895.* On 14 of the 20 farms a nitrogenous manure paid well and the average effect of a dressing of ½ cwt. nitrate of soda used with farmyard manure, 2½ cwt. superphosphate and 2 cwt. kainit was as follows:—

		1894. 11 farms. T. C.	1895. 9 farms. T. C.
16 loads dung	+ complete artificial mixture ...	18 19¾	22 9
Do.	+ **nitrate omitted** from artificials	17 10½	21 0½
Average effect of ½ cwt. nitrate of soda		1 9¼	1 8½

Summary.—

(1) In continuation of similar experiments made in 1900, experiments on the root crop were carried out at thirteen centres last season.

(2) Although on the average a phosphate proved the most important ingredient of a mixed manure, it has only held the first place on thirteen out of twenty-four soils tested in the two years; potash stood first at six and nitrogen at five centres.

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* *Fourth Annual Report*, p. 57.

(3) These figures indicate widely different manurial conditions in the soils tested and show the necessity for systematic tests by farmers who wish to use artificial manures economically. Soil tests may very easily be carried out on swedes or turnips; the treatment should take the form shown in Table B, page 12. Farmers who study the effects produced by different manures on roots, may learn what their land is likely to want for corn crops and clover.

(4) Those farmers who are obliged to grow roots without farmyard manure, and who have not tested the action of the different artificials will find the following a good mixture:—

1 cwt.	Nitrate of Soda ...	12¾ cwt., costing 43s. to 48s. to be applied in the drill when sowing.
¾ ,,	Sulphate of Ammonia	
7 ,,	Superphosphate ...	
4 ,,	Kainit	

This quantity is suitable for one acre of inferior, for 1½ acres of good and for 1¾ acres of very good loam. On thin, hungry soils 1 cwt. of fish meal may be used in place of ½ cwt. nitrate of soda. On light land, poor in lime and liable to finger-and-toe, precipitated bone phosphate or a similar manure may be used for superphosphate. On heavy or damp soils slag should be used in place of superphosphate.

(5) For a comparison of the effects of different phosphates see Table C, page 16.

(6) Contrary to our expectation better root crops have been grown by good artificial mixtures than by 12 tons farmyard manure; in the wet season of 1900 on eight farms out of ten, in the dry season of 1901 on seven farms out of eleven. This does not show that dung can be dispensed with (corn crops and clover have to be considered), but that

light manures make a good substitute for growing roots. The failures so often complained of must usually be ascribed to the improper use of artificials. When a light manure fails, a farmer, before condemning it, should ask himself the question, "Has the manure been properly compounded, have the nitrogen, phosphates and potash been mixed in suitable proportions?" Unless he satisfies himself on this point he has no more right to complain of the manure than the ploughman has to accuse his plough of being responsible for an indifferent furrow.

(7) In Durham and Northumberland the climate is favourable for roots and a dressing of 12 tons dung has usually produced a full crop. Artificials have seldom proved directly profitable on this crop, at the same time when phosphates are required to maintain fertility (as they certainly will be on most farms) our experiments prove that they should be applied with dung for roots. If phosphates are used with dung our experiments show that a direct profit may be obtained from a nitrogenous manure. As regards potash it seems likely that on most farms where dung is freely used it may be omitted from the mixture for roots; as, however, this omission might injure the following clover crop, it is on the whole safer for a farmer, who has not tested the question, to use a small quantity of kainit.

(8) As a supplement to 12 tons per acre of moderately rotted dung the following artificial mixture would be suitable under average conditions:—

½	cwt.	Nitrate of Soda ...	per acre.	Cost, about 28s.
¾	„	Sulphate of Ammonia		
5	„	Superphosphtae ...		
2	„	Kainit		

II.

EXPERIMENTS ON POTATOES.

(TABLE III.)

Experiments on the potato crop were carried out in season 1901 at the nine centres named in the following table:—

TABLE A.

No.	Farm.	Occupier.	Remarks.
1	Broomhaugh, Riding Mill	Mr. C. Marshall	"Up to Date" on gravelly soil after two years' lea.
2	Sands Hall, Sedgefield	Mr. R. Ord ...	"Up to Date" on gravelly soil after oats after turnips.
3	Brandon House, Ferryhill	Mr. J. J. Furneis	"British Lion" on gravelly soil after lea after barley.
4	Byers Garth, Durham	Mr. T. Oswald...	"Scottish Triumph" on sandy soil after oats after lea.
5	Broomside House, Durham	Mr. T. Cleasby	"Up to Date" on sandy loam after oats on lea after wheat.
6	Diamond Hall, Sedgefield	Mr. G. Bell ...	"Up to Date" on clay soil after two years' lea.
7	Neasham Grange, Darlington	Mr. R. Humphrey	"General Roberts" on rich alluvial soil after oats.
8	Acklam, Stockton ...	Mr. W. Humphrey	"General Roberts" on sandy soil.
9	Blakelaw, Gosforth	Mr. J. Hunter...	"British Queen" on sandy loam after oats.

The objects of the experiments were:

(1) To indicate the class of manure most necessary for successful potato-growing in the Northern Counties.

(2) To ascertain in what proportions nitrogenous, phosphatic and potash manures should be mixed.

(3 To compare the effects of the three common potash manures.

(4) To compare the results of using dung alone, artificials alone, and combinations of the two.

(5) To test the effect of certain of the manures on the quality of the tubers.

The dry season was favourable to the potato plant, and very heavy crops were lifted at several of the centres. The season also favoured the action of certain of the manures, and the results were well marked at most of the stations. The tubers when lifted were classed into 3 sizes by means of 1⅝ inch and 1¼ inch riddles, except at Acklam, where two sizes only were separated. Table III. gives the aggregate crop of "ware" and "seconds" lifted at each centre. Potatoes passing through 1¼ inch riddle have not been included; the quantity was small, and did not vary much at the different stations.

The land at Neasham was in such high condition that the unmanured plot yielded nearly 12 tons per acre; under such circumstances the action of manures could not be compared. At Blakelaw too, and at Acklam the soils were rich and the crops somewhat irregular. The results at these three stations have been excluded from the average column in Table III. On the six remaining stations the crops were satisfactory, and the average returns per plot are given at page 128, and also in Tables B, C and D.

Every station was visited during the autumn. The appearances of the crops were then found to be more instructive even than the figures subsequently furnished by the weighbridge. Some of the characteristic effects of the manures will be referred to later on. When the crops were lifted samples, consisting of 50 average tubers, were taken from the produce of certain of the plots. The effect of the manures on the proportion of dry matter was determined by Mr. Collins, and a reference to the subject will be found at p. 109.

What Class of Manure is most Necessary?

In attempting to frame an economical mixture for potato growing the farmer's first object should be to gain some conception of the relative importance of nitrogenous, phosphatic and potash manures on his own land. In general, he will find the first class of manure of greater, the second class of much less, and the third of much greater value for the potato than for the turnip; but a trial made on the latter crop is not sufficient to show the characteristic needs of the former. These needs must be gauged by means of some such simple test as that dealt with in Table B. This table shows the average crop produced on six farms by a "complete manure," and the effects of omitting in turn each class of manure—nitrogenous, phosphatic and potassic.

TABLE B.

Plot.	Treatment per Acre.	Cost of Manures.		Yield of Ware and Seconds.		Increase produced by Manure.		Profit due to Manure. Potatoes 50/- per ton.	
		s.	d.	T.	cwt.	T.	cwt.	£	s.
12	No manure	...		4	18½	...		...	
5	1⅛ cwt. nitrate of soda, ⅞ cwt. sulphate of ammonia, 3½ cwt. super., 1⅜ cwt. sulphate of potash **(complete manure)**	38	0	8	2¼	3	3¾	6	1
13	Same as Plot 5 but **no nitrogen**	18	3	6	14	1	15½	3	10
14	,, ,, **no phosphates**	27	3	7	10¼	2	11¾	5	2
15	,, ,, **no potash**	30	6	5	5¾		7¼	*Loss*	11

After deducting the cost of the dressing the crop grown with a complete fertilizer was worth 121s. per acre more than the produce of the unmanured plot. The omission of superphosphate reduced this profit to 102s., and the omission of the two nitrogenous manures reduced the profit to 70s. The nitrogenous manures proved as was anticipated much more needful than the phosphatic, but these in their turn were less required by the potato than the manure supplying potash, for when 7s. 6d. worth of sulphate of potash was omitted from the complete manure used on Plot 5, the profit of 121s. was converted into a loss of 11s. per acre; a saving of 7s. a loss of nearly £7! These average results indicate the relative positions of the three manures on almost every station. At eight out of nine centres superphosphate proved least necessary, and at seven out of nine sulphate of potash proved most necessary. Two of these exceptions occurred at Acklam and Blakelaw, and were probably due to the unsuitable character of the fields experimented on. The third exception was at Sands Hall. Here, on a light soil, which the "swede" experiment has shown to be very poor in nitrogen (see Table II.) the want of potash did less injury to the potato crop than the want of nitrogenous manures. The greatest need for a free use of potash was shown by the two farms near Sherburn Colliery and by the light alluvial soil of Broomhaugh, Riding Mill. On these farms the produce of Plot 15 ripened off early, and not only was the total crop scanty, but an eighth of the whole consisted of small potatoes, whereas the proportion on Plot 5 manured in a similar way, but with the addition of potash, was reduced to one-fifteenth.

Potatoes and Swedes Compared.—

At Neasham Grange we were able to contrast the manurial requirements of the potato and the swede. The two crops were grown within a few yards of each other under precisely similar conditions as regards soil and manure, with the following results :—

	Potatoes.		Swedes.	
	T.	C.	T.	C.
Complete artificial manure ...	13	19	22	2
Do. omitting nitrogen ...	13	4	22	8
Do. do. phosphates ..	13	6	11	4
Do. do. potash ...	13	2	20	5
No manure	11	15	11	17

The contrast is interesting as showing the very different power the two plants have for assimilating phosphates. Here we have a soil so rich as to be able to grow $11\frac{3}{4}$ tons of potatoes without manure ; so rich that a full application of manure only increased the crop by 2 tons, and yet the swede was unable to find in it the requisite supply of phosphates, so that the omission of superphosphate from an artificial mixture reduced the crop by 50 per cent. and rendered it unable to derive any benefit from a full application of nitrogenous and potash manures. The experiment indicates that the potato is much more able to avail itself of soil phosphates than the swede, and is therefore much less dependent on a generous supply of phosphatic manures.

It has been shown in Table B that the particular manure used on Plot 5 gave a much greater profit than any of the "incomplete" mixtures, but the particular mixture used on Plot 5 was only one, and not the best one, of a series of complete manures used in the experiment. The results obtained from the use of different complete manures are shown in Table C.

TABLE C.

Plot.		Cost of Manure.		Yield of Ware and Seconds per acre.		Increase produced by Manure.		Profit due to Manure. Potatoes 50/- per ton.	
		s.	d.	Tons.	Cwt.	Tons.	Cwt.	£	s.
12	No manure	...		4	18½	...		...	
5	Complete manure { 1⅛ cwt. nitrate of soda ⅞ „ sulp. ammon. 3½ „ superphos. 1⅜ „ sulph. potash }	38	0	8	2¼	3	3¾	6	1
6	Twice as much **nitrogen** as Plot 5, all supplied as **sulphate** of ammonia	51	9	8	5¾	3	7¼	5	16
7	As Plot 6, but all nitrogen from **nitrate** of soda	64	0	8	9½	3	11	5	13
8	Twice as much **phosphates** as Plot 5, supplied as superphosphate	49	6	8	2¼	3	3¼	5	10
9	Twice as much **potash** as Plot 5, potash supplied as **sulphate**	45	6	9	1	4	2½	8	1
10	As Plot 9, but potash supplied as **muriate**	48	0	9	10¾	4	12¼	9	3
11	As Plot 6, but potash supplied in **kainit**	46	9	8	16½	3	18	7	8

The results of using twice as much nitrogen as on Plot 5 first in sulphate of ammonia and then in nitrate of soda, have not been satisfactory, and in neither case has the slightly increased crop paid for the extra manure. Forty pounds per acre of nitrogen in the form supplied to Plot 5 was sufficient to produce the maximum crop which most of the soils were capable of producing in the past season, and though in a wet year more might prove profitable, this quantity may be looked upon as sufficient for ordinary use. The heavy dressings applied to Plots 6 and 7 produced a very gross haulm and were expected to injure the quality, but so far as the testing has gone the injury to quality is not marked, and the objections to using more than 40 to 45 lbs. nitrogen per acre, are that in most cases it will not prove profitable, and that it might render the crop liable to potato disease.

The dressing of superphosphate used on Plot 5 was a very moderate one, but our experience in 1900 showed us that it was as much as an ordinary crop of potatoes would require, and we were prepared for the result obtained from Plot 8. At no farm had we any evidence that increasing the superphosphate from 3½ to 7 cwt. per acre improved the crop, and on the average we got exactly the same yield from Plots 5 and 8, and, of course, a diminished profit from the manure used for the latter.

When we double the dressing of potash manure as we do on Plots 9, 10 and 11 we find that in every case there is a considerable increase and a substantially greater profit, and we have clear evidence that in the absence of farmyard manure 50 lbs. of potash is not enough for an acre of potatoes; double this quantity proved profitable, and in 1901 the best artificial mixture for potatoes was:

1⅛ cwt. nitrate of soda ...
⅞ „ sulphate of ammonia
3½ „ superphosphate ...
2 „ muriate of potash ..
} per acre, costing about 48s.

The Most Suitable Potash Manure.—

The result indicated above is similar to the result of increasing the potash in 1900, but in the dry season, 1901, the extra dressing of potash proved more beneficial than in the previous year. This is shown in the following comparative statement:

Complete Artificial Manure.	Crop per acre.		Increase due to increasing Potash.	
	1900	1901	1900	1901
	T. C.	T. C.	T. C.	T. C.
Supplying 50lbs. potash per acre in **sulphate**	7 2½	8 2¼	...	...
Do. 100lbs. do. do. do.	7 19	9 1	16½	19¼
Do. 100lbs. do. do. **muriate**	7 13¼	9 10¾	10¾	1 8½
Do. 100lbs. do. do. **kainit**	6 12½	8 16½	—*10*	14¼

In the moist summer of 1900 sulphate of potash proved best, muriate of potash stood second and kainit was quite inferior, in the dry summer of 1901 the more soluble muriate of potash was better than sulphate, and both were again better than kainit. In 1900 kainit was found to hasten the ripening in a very marked degree at several centres. In 1901 this effect of the manure was equally well marked at one station only—Neasham Grange—but indications of this tendency were seen elsewhere. It was shown in last Report that the free use of kainit lowered the quality of the crop, some further analyses bearing on this subject will be found on p. 128, and in the Report of the Northumberland County Council Farm it will be shown that at Cockle Park, where an experiment of the kind now being described, was carried out in 1901, the potatoes grown with kainit were very inferior in quality to those grown with muriate or sulphate of potash. The free use of kainit for potatoes cannot be recommended. Sulphate and muriate of potash are much more suitable fertilizers for the potato crop. In a very dry season the greater availability of kainit gives it an advantage over sulphate of potash, and at three out of nine farms tested in 1901 the former produced rather the heavier crop, but taking the influence on quality into account, farmers who wish to apply potash freely would be well advised to leave kainit alone and to employ either muriate or sulphate. As between these two latter manures there is very little to choose. On 5 farms in 1900 they were twice practically equal, twice sulphate did best and once muriate; on 9 farms in 1901 muriate was best 7 times, and once only (at Broomhaugh) was sulphate distinctly the more profitable. The potato crop tells very plainly how a particular manure suits it, and in both seasons the harvest results were anticipated from the appearance of the growing crops. In 1900 the "sulphate" plot at certain of the stations stood out as distinctly better than the others; but early in the growing season of 1901 it was remarked that the "muriate" plot was doing relatively better than in the previous season, and the notes made during the autumn show that at nearly all centres Plot 10 (muriate) was equal to Plot 9 (sulphate), with a tendency to earlier ripening at Brandon House, Blakelaw and Neasham Grange, but that at Broomhaugh, Plot 10, was "distinctly less vigorous, and earlier than Plot 9." It is worth noting that both the crops on which sulphate did better than muriate in 1901 followed lea, and that on the average of the three "lea" stations sulphate was the better manure. After lea the soil would contain more "fibre" and more moisture than after corn. The cooking tests and analyses show that potatoes grown with muriate and sulphate of potash are very similar in quality. Where muriate induces early ripening* there will usually be less dry matter, but the decrease will be trifling, and may, in practice, be neglected. As regards both quality and quantity therefore, the advantages are evenly balanced, in dry seasons the muriate and in moist the sulphate is likely to do best; this being the case, if the market prices per unit are similar the farmer may be recommended to use both. When manures are equally suitable for soil and crop and when one suits a dry and the other a damp season, it will always be found safer to use both.*

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* The early ripening induced by muriate of potash and kainit seems in both cases to be due to the action of chlorides, the greater effect of the latter being due to the greater quantity of chloride applied. In 8 cwt. kainit there would be about as much chloride as in 5 cwt. common salt; in 2 cwt. muriate of potash, about one-third of this amount.

Farmyard Manure v. Artificials.—

In previous experiments farmyard manure has been valued at 5s. per ton, but as it is certain that on most farms the succeeding crops derive much greater advantage from the home manure than from the purchased artificial, farmyard manure has here been put at 2s. 6d. per ton. Partly for this reason but chiefly because of the dry summer, farmyard manure shows to much greater advantage than in the experiments of the two previous seasons. By far the best average result in 1901 has been obtained from the use of 18 tons manure, and the second best in point of profit was from 12 tons. It will be seen from Table D that the former dressing has produced nearly 3 tons and the latter 1½ tons more crop than the best of the artificial mixtures. Both in 1899 and 1900 artificial manures grew larger crops than did 12 tons dung. In 1900 a dressing of 18 tons of dung was not applied, but in 1899 it was used in conjunction with artificials, and at p. 48 of the Report for that year it is remarked that "for every ton of dung used beyond 12 tons per acre only 1s. 3d. worth of crop was produced." We have to go back to an experiment made at Cockle Park in 1898 for results as favourable to dung as those of 1901.

The crops furnished evidence that the special value of dung last season was due (1) to the abundant supply of potash contained by this manure; and (2) to its effects on soil moisture. In 1900 the difference in the appearance of the plots receiving 12 tons dung and artificial mixtures only, was not marked during the growing season, but in 1901 there was a striking difference between these plots (2 and 5), at the majority of the stations. The haulms of the crops growing on Plot 5 (artificials only) were much smaller and paler in colour than those on Plot 2, and they nearly always ripened earlier. On those stations where the contrast was most marked (Broomside, Byers Garth, Brandon House, Sands Hall) it was noticed that increasing the dressing of potash in the artificial mixture greatly altered the appearance of the crops, so that on Plots 9 and 10 the haulms were scarcely to be distinguished from those of Plot 2. Indeed if a visitor had been shown the effects produced by farmyard manure on Plots 1 and 4 and the effects produced by artificials containing the smaller supply of potash on Plots 5 and 8, he would at once have inferred that Plots 9 and 10 had received dung. That farmyard manure was of value in assisting the crop through the dry season may be inferred both from general principles and from the fact that on the clay soil of Diamond Hall and the deep alluvium of Neasham Grange dung was of little value, whereas it exerted its greatest influence on gravel at Sands Hall and sandy soil at Byers Garth.

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* "When in doubt use both," is a useful maxim that may be acted upon, not only in the case of the two potash salts, but when dealing with slag and superphosphate, nitrate of soda and sulphate of ammonia, or any two manures of the same class whose particular suitability is a question of season *not of soil.*

On p. 28 of last year's Report it was stated that "when the potato occupies a portion of the fallow break, dung should be used, when it does not . . . . fold manure may sometimes with advantage be omitted and artificial manures only used." In spite of the excellent crops produced by farmyard manure in 1901 the above opinion may be adhered to. On three of the farms last season potatoes did *not* occupy a part of the fallow break; they were grown after lea at Broomhaugh, Brandon House and Diamond Hall. Two of these soils were gravels, the third a clay. The crops grown were:—

		T.	C.
With 18 tons farmyard manure	...	10	5
Do. 12 do.	...	8	16
Do. the best artificial mixture*	...	8	11

Thus a good artificial mixture has produced a crop only 5 cwt. less than that grown with 12 tons dung, and this in a season particularly favourable to the latter manure. In view of this result it would be unwise to rob the fallow break of its manure for the sake of the potato crop. We have already seen, p. 17, that the root crop may easily be grown to perfection with artificials, but in manuring the fallow crop we must keep the following corn and clover crops in view, and a farm that receives dung for the fallow crop is likely to keep its condition better than one on which the dung is used for "lea" potatoes.

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* In the case of these three farms Plot 9.

In discussing the effects of season on the root crop it was shown that dung had been less beneficial in the dry summer of 1901 than in the moist one of 1900, in the case of potatoes we have just seen that exactly the opposite was the case. The apparent contradiction is doubtless due to the fact that the potatoes were planted a fortnight to three weeks before the swedes were sown, and before there was any risk of letting "the drought" into the drills.

Farmyard Manure v. Farmyard Manure and Artificials.—The average crops grown without manure, with the best artificial mixture, with dung, and with dung and artificials are shown in Table D. The profit due to the manures (the potatoes being valued at 50s. per ton) is also given.

TABLE D.

Plot.	Treatment per Acre.	Cost of Manure.		Yield per Acre. Ware and Seconds.		Increase produced by Manure.		Profit due to Manure.	
		s.	d.	T.	C.	T.	C.	£	s.
12	No manure	...		4	18½	...		...	
10	1⅛ cwt. nit. of soda, ⅞ cwt. sulph. am. 3½ „ superphosphate ... ... 2 „ muriate of potash	48	0	9	10¾	4	12¼	9	3
1	18 tons farmyard manure	45	0	12	8¼	7	9¾	16	9
2	12 „ „ „	30	0	10	19¾	6	1¼	13	13
3	12 „ + half artificial mixture of Plot 4	49	0	11	3¾	6	5¼	13	4
4	12 „ + 1⅛ cwt. nit. of soda, ⅞ cwt. sul. am. 3½ „ superphosphate .. 1⅜ „ sulp. of potash ...	68	0	11	12¼	6	13¾	13	6

In both 1899 and 1900 artificials when used along with dung left a handsome profit; last season they did not pay. If potatoes had been worth from 70s. to 80s. per ton the mixtures would have repaid their cost, and in view of past experience the use of an artificial manure in addition to 12 and even 18 tons of dung is to be recommended. The following would be suitable with the smaller quantity of farmyard manure:—

1¼ cwt. sulphate of ammonia ... ... *or* ¾ cwt. sulphate and ½ cwt. nitrate of soda 2½-3 cwt. superphosphate ... ... 1 cwt. muriate of potash	per acre, costing about 30s.

Effects of Manuring on Size of Tubers.—

As already stated, the potatoes were sorted over 1⅝ inch and 1¼ inch riddles, and so separated into three sizes. In Table E the average percentage of ware, seconds and small on certain of the plots is given.*

TABLE E.

Plot.	Treatment per Acre.	Total yield per acre.	Percentage of Total.		
			Ware.	Seconds	Small.
		T. c.			
1	18 tons farmyard manure	12 12½	87·1	9·3	3·6
2	12 „ „ „	11 6¾	86·0	11·0	3·0
4	Do. + complete artificial mixture ...	11 19	89·1	8·0	2·9
5	Same as Plot 4 but without dung ...	8 9¾	81·5	14·0	4·4
10	Same mixture as Plot 5 but double potash as muriate	9 17¾	87·0	9·5	3·5
15	Same as Plot 5, omitting potash	5 14¾	75·4	16·8	7·8
14	„ „ „ „ phosphates ...	7 17¼	82·1	13·4	4·5
13	„ „ „ „ nitrogen ...	7 2½	78·2	15·8	6·0
12	No manure	5 6½	69·0	23·5	7·5

* The Potatoes averaged were "British Lion" and "Scottish Triumph" on one farm each, and "Up-to-Date" on four farms.

In the case of a crop plentifully supplied with potash whether in dung or in artificials only (Plot 10) the percentag of large potatoes was from 87 to 89 per cent., and of small fro 3 to 4 per cent. The reduction from 100 lbs. potash to 50 lb per acre (Plot 5) reduced the size of the potatoes very considerably, and the omission of potash altogether (Plot 15) ha not only diminished the crop by nearly one-half, but has reduced the proportion of large potatoes by 12 per cent. Th omission of phosphates (Plot 14) has not affected the size o the potatoes, though it has somewhat reduced the crop; bu where nitrogen has been left out of the artificial manure, th number of small potatoes has been considerably increased. I will be remarked in the above table that the percentage o "chats" is very constant; only on one plot does it sink belo 3 per cent. and on two only does it rise above 6 per cent. Th chief variation in Table E is in the "seconds" column, and i reading the figures it must be remembered that a reduction i size need not necessarily be a disadvantage in the case of thos potatoes whose "setts" are worth as much as, or even mor than, their "ware."

Summary.—

(1) In continuation of similar experiments made i 1900, experiments on the potato crop were conducted at nine centres in 1901.

(2) On the majority of the soils tested potash was foun to be the most important component of a compound manure for potatoes; but its relati importance varied widely and this variatio indicates the necessity of adapting mixe manures to the particular soils on which the are to be used. It is only by making field trial that the most suitable mixture can be discovere

(3) The best average mixture for growing potato when dung is not available is given at p. 29 This mixture would cost about 48s. per acre.

(4) The sulphate and muriate of potash are more suitable potato manures than kainit. The latter when freely used is apt to injure the quality of the crop.

(5) In the dry season 1901 farmyard manure proved much more valuable than any of the mixtures of artificials, and 18 tons proved more profitable than 12 tons.

(6) As compared with artificial mixtures the value of farmyard manure for potatoes is largely due (1) to its effect on soil moisture, (2) to the abundant supply of potash furnished by a full dressing. When the moisture conditions are favourable (as after lea) first-rate crops may be grown with suitable artificials.

(6) As a general rule the bulk of the dung produced on a farm should be applied to the fallow crop, and potatoes grown after two or more years' lea should not receive dung unless the needs of the fallow have been fully met.

(7) Potatoes nearly always pay for artificials used to supplement dung. A suitable average dressing for use with 12 tons of dung is given at p. 35.

(8) The effect of manures on the size of the tubers is shown in Table E, p. 35.

POTATO SPRAYING EXPERIMENTS AT ABBEY HOLME.

The usual experiments in the spraying of potatoes in the Abbey Holme district under the Technical Education Scheme of the Cumberland County Council, have been again carried out. The potatoes sprayed this year were on a gravelly loam after oats. The season was much too dry, and the early varieties suffered from drought. Contrary to the general experience, this year the "Bruce" variety turned out a heavier crop than the "Up-to-Date;" the latter, however, contained a much larger proportion of marketable tubers. The potatoes were sprayed on 29th July, 12 lbs. of sulphate of copper with the necessary quantity of lime being mixed with 80 gallons for the early crops, and 100 gallons of water and 15 lbs. of sulphate for the late varieties. In the case of early varieties the spraying lengthened the growth about a fortnight, in the late varieties no difference was perceptible. The following are the results:—

Variety.	Sprayed.			Unsprayed.			Gain.		
	Tons	cwt.	st.	Tons	cwt.	st.	Ton	cwt.	st.
Early Puritan ...	5	0	5½	3	17	5	1	3	0½
Myatt's Kidney ...	5	10	6	4	10	4	1	0	2
Up-to-Date	14	1	1	12	19	0	1	2	1
Bruce...	14	7	1	14	3	0	0	4	1
New Champion ...	10	14	6	9	8	3	1	6	3

EXPERIMENT ON MANGELS.

An experiment on the mangel crop was carried out on the farm of Mr. H. Simpson at High Rockcliffe, Croft. The plots were of the same size as for the turnip and potato experiment, viz., $\frac{1}{27}$th acre. The produce of $\frac{1}{40}$th acre was weighed. The soil was level and on the whole uniform, but was in very high condition and too rich for experimental purposes. The unmanured land produced no less than 20 tons per acre.

The following is a summary of the results:—

(1) A dressing of 12 tons dung produced an increase of 67 cwt. over the untreated plot.

(2) 20s. worth of mixed artificials further increased the crop by 28 cwt., and 40s. worth of the same mixture by 86 cwt.

(3) Top-dressing the nitrate of soda was distinctly profitable as compared with application in the drill. The yield was increased by 60 cwt. in one case and by 31 cwt. in another.

(4) Kainit gave a better return than muriate of potash.

(5) Salt very materially benefited the crop.

(6) The best crop, 35 tons 14 cwt. per acre, was produced by the following manuring:—12 tons dung, $\frac{7}{8}$ cwt. sulphate of ammonia, $1\frac{1}{8}$ cwt. nitrate of soda, 4 cwt. superphosphate, $\frac{3}{4}$ cwt. muriate of potash, and 3 cwt. salt. The artificials cost about 43s.

EXPERIMENTS ON SEEDS HAY.

(TABLE IV.)

Experiments were conducted at the farms named in Table A with the object of testing the value of nitrate of soda, sulphate of ammonia, superphosphate and muriate of potash as spring top-dressings for seeds hay.

TABLE A.

No.	Farm.	Owner or Occupier.	Remarks.
1	Diamond Hall, ... Sedgefield	Mr. G. Bell	Fair take after Oats on clay loam
2	Hesledon Farm ...	Messrs. Nimmo & Co.	Fair take after Oats, plants, especially Italian Rye-grass strong, soil light loam
3	Hall Farm, Sherburn Colliery	Mr. English ...	Soil gravelly loam. Seeds good, grass predominating after Barley.
4	Byers Garth, Durham	Mr. T. Oswald ...	A. On Wheat stubble, on clay soil, full of clover and a strong plant. B. On Barley stubble on a sandy loam, Rye-grass very good.
5	Newlands Haugh,... Ebchester	Derwent Flour Mill Co. (Manager Mr. Hamilton)	Good and very even take, (Rye-grass predominating) after Barley on rich Alluvial soil.
6	Low Bradley, ... Medomsley	Mr. W. Fenwick ...	Poor thin clay soil, after Oats.
7	East Farm, ... Medomsley	Mr. Geo. Bell ...	Medium soil. A fair take of seeds after Barley, plenty of clover.
8	Springs House ...	Mr. H. G. Fenwick	Even take, soil clay, after Wheat, after Swedes.
9	Manor Farm, ... Usworth	Mr. W. McLaren ...	Even take, strong loam after Wheat after turnips.

Previous experience had taught us that the seeds crop was a troublesome and somewhat unsatisfactory one to experiment upon, and great care was taken by Mr. Greig in selecting suitable fields for last season's trial. As clover is very apt to go off in April and May and it is not so easy to pick out an even piece of land for a seeds experiment as for experiments on the root crop, it was resolved to carry out all these hay experiments in duplicate. At each station there were 20 $\frac{1}{20}$th acre plots arranged in two series A and B. At one station (Byers Garth) the two sets of plots occupied two different parts of a large field and as the soil and previous treatment differed (see Table A) they were not duplicates. At one station, Diamond Hall, the plots were arranged thus:—

1, 5, 9, 3, 7,
A 2, 6, 10, 4, 8, B
3, 7, 1, 5, 9,
4, 8, 2, 6, 10,

At the remaining stations they were arranged in two long lines thus:—

A 1, 2, 3, 4, 5, 6, 7, 8, 9, 10,
B 6, 7, 8, 9, 10, 1, 2, 3, 4, 5,

Plots having the same number received the same treatment, and were always placed some distance apart.

Manuring and Weighing.—

The scheme of manuring will be found in Table IV. Nitrate of soda was applied in the end of April or the beginning of May, under the supervision of the occupier of the farm, the other manures 3 weeks to a month earlier, in presence of a representative of the College, who as usual marked off and numbered all the plots before leaving the field.

The crops were cut towards the end of June and they were weighed when fit to stack. In 1900 the grass was weighed as soon as cut and the weight of hay calculated, but this method was departed from in 1901 as it is open to several objections.

From the actual weight of hay 12½ per cent. has been deducted as representing shrinkage in the stack, and the corrected weight is given at page 129. The figures are probably in all cases 5 to 10 per cent. too high. Last summer, hay came into condition for carrying very quickly and in a number of tests made at Cockle Park, it was found to lose 15 to 25 per cent. of its weight after standing in the stack for six weeks. The loss, whatever its amount, would be very nearly the same for all the plots of a station and scarcely affects the experiment. The profit (obtained by valuing the increase over the manured plot at 60s. per ton and deducting the cost of the manure) will be somewhat greater than for hay weighed out of the stack six months later, but is about equal to the profit that would be obtained from selling hay in spring at 70s. per ton.

The season was favourable for hay on medium and heavy soils and the crops generally were very good; but light land suffered from the dry weather and at one or two centres, where patches of gravel occurred below the plots, the harvest results were of no value for comparative purposes.

Inspection of Plots.—

All the plots, with the exception of those at Diamond Hall, were inspected early in June, and for reasons given below it was decided to exclude some or all of the results of the hay-weighings given at page 129 from the average column. Some of the results which have been admitted may not appear consistent, but they have been included because they indicate with sufficient nearness the actual benefit felt by the crop on each particular farm. In including or excluding figures the appearance of the growing crop has been borne in mind, and the weights given in the "average" column of Table IV. are believed to represent very closely the "average" effects of using the different manures last season.

Into the "averages" from which the profits have been calculated, figures from the following plots have entered: Diamond Hall, Low Bradley, Newlands Haugh, West Farm, Medomsley, B Plots; and Springs House, Birtley, Plots 1-5 A and 6-10 B. The other stations or plots have been excluded for the following reasons:—

Hall Farm: Gravel patches in field.

Hesledon: Soil variable at both sides of field.

Usworth: Land in very high condition and not uniform.

Birtley: Plot 8 A did not receive nitrate and 9 looked as if it had got double quantity.

Medomsley: Plot 4 A did not receive nitrate, it was put on 5 A.

Byers Garth: Nitrate of soda intended for Plots 3, 4, 7, 8 and 9, went on Plots 4, 5, 8, 9, and 10. This mistake has affected the results of Plots 3, 4, 5, 7 and 10.

Those plots belonging to Series A at Byers Garth, which were not affected by the wrong use of nitrate, viz., 1, 2, 6, 8 and 9 with the corresponding "A" plots at Medomsley and Plots 1, 2, 8 and 9 B and 6 A at Hesledon have, together with the eight satisfactory plots at the other centres, been included in a second column of averages in Table IV. Except where otherwise mentioned the averages referred to below are those from the first column.

Sulphate of Ammonia and Nitrate of Soda.—

The detailed results and the averages in Table IV. show that these nitrogenous manures were much more effective than either potash or phosphates in increasing the hay crop. A summary of the results obtained from using them both separately and mixed is given in Table B.

TABLE B.

Compare Plots.	Increase per acre produced by	Cost of Manure.		Hay.	Profit, Hay 60s. per ton.	
		s.	d.	cwt.	s.	d.
2 & 1	1½ cwt. sulphate of ammonia over unmanured land	16	9	13½	23	9
3 & 1	2 cwt. nitrate of soda over unmanured land	17	9	10¾	14	6
4 & 1	¾ cwt. sulphate of ammomia and 1 cwt. nitrate soda over unmanured land	17	3	13¾	24	0
7 & 5	¾ cwt. sulphate of ammonia and 1 cwt. nitrate soda with super over super. alone	17	3	13½	23	3
8 & 6	¾ cwt. sulphate of ammonia and 1 cwt. nitrate soda with muriate over muriate alone	17	3	12¾	21	0

In 1900 nitrate of soda was distinctly more profitable than sulphate of ammonia, last season the positions were reversed and sulphate gave the best returns, probably because it was applied three weeks before the other. April 1901 was a bright, warm month and sulphate of ammonia began to exercise an effect ten days after application. Growth started early in the season and owing to the very dry weather it stopped early, so that nitrate applied in the end of April had not so much time to influence the crop as it would have had in a season of less sunshine and more rain.

A mixture of sulphate and nitrate produced slightly better results than sulphate by itself, and it is instructive to notice that in the previous season, when nitrate was the better of the two nitrogenous manures, the mixture was, as in 1901, best of the three. In ordinary circumstances one might suppose that a mixture of two similar fertilizers would produce results intermediate between the two, but here we find that the mixture of sulphate and nitrate is more than the equal of the best of the single manures. Our experiments show that:

	1900. cwt.	1901. cwt.	Total. cwt.
Sulphate of ammonia produced an increase of ...	9½	13½	23
Nitrate of soda produced an increase of	12	10¾	22¾
Mixture produced an increase of	12½	13¾	26¼

Thus a farmer who had used nitrate only and one who had used sulphate only in 1900 and 1901 on the "average" land on which the experiments were made, would have made almost the same profit. But if one of them had divided his custom between the two nitrogenous manures he would now have been better off than his fellow by the value of 3 cwt. of hay. Whenever nitrate and sulphate can be purchased on equally favourable terms,* the average farmer will find it profitable to use both.

Effect of Heavy Dressing of Nitrogenous Manures.—

This is a subject that requires close attention on the part of the farmer for although heavy dressings of sulphate of ammonia and nitrate of soda may be most profitable when skilfully used, their use is attended with certain dangers. The clovers are very liable to injury and even the grasses may suffer in quality.

Clover is not at first injured in any way by the free use of nitrogenous manures. As the result of top-dressing ryegrass grows quickly, and directly the grass starts the clover begins to spring, so that by the 1st of May clover on top-dressed ground looks much better than it does on untreated land. By the end of May the grass on land that has been top-dressed early in April is much longer than where manures have not been used; but the clovers are less prominent, and though taller are less branched and somewhat less vigorous.

In the middle of June last year all the plots were inspected, and at that time, although clover was in certain cases less abundant when nitrate or sulphate had been used, it appeared on the whole to have suffered little injury from the treatment. When the aftermath was visited a very different state of affairs was discovered. In some cases it was found the use of sulphate or of nitrate for the first crop had entirely destroyed the clover plant, and at Newlands Haugh, Low Bradley and Hall Farm,

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* When Sulphate of Ammonia is selling at £12 per ton, Nitrate of Soda is worth £9.

Sherburn for example, the outline of the plots that had received these manures could be plainly traced. The boundary of the plots looked as if a line had been stretched between the corner pegs and all the clover plants on one side had been pulled up.

At other stations, as at Usworth and Byers Garth ("A" plots), the aftermath did not suffer. At the latter station Plot 4 received, by mistake, 2 cwt. nitrate of soda and ¾ cwt. sulphate of ammonia per acre, but the clover in the second crop was nearly as abundant as on the adjoining unmanured plot.

Further experiments are being made and it is hoped that more definite information will be available next season, but for the present the following points may be noticed.

Clear, frosty nights followed by bright sunshine in April and May are well known to be trying to clover, and the taller, more tender plants on top-dressed plots may be more susceptible of injury than the backward plants on unmanured land. There is no question that top-dressing makes clover, as well as grass, earlier, and this early "drawn" clover appears to be less hardy than the ordinary plant. It is probable that in seasons when night frosts are numerous the tender character of forced clover is responsible for some of the disappearance. At the same time it must be pointed out that this clover is much better sheltered by grasses in the earlier part of the season than clover on untreated land.

Apart from the risks incident to the crop from frosty nights in the month of May, it is unlikely that a "drawn" and tender clover plant will produce strong, new shoots and a vigorous aftermath after cutting. These considerations account for the minor degree of deterioration of clover noticed on the top-dressed plots at nearly all the stations last summer, but they are scarcely sufficient to account for the sudden and complete disappearance seen at some of the centres, and the fact that the clover stood well on the deeper and richer soils and went off altogether on certain of the light land plots, indicates that want of moisture was the chief cause of failure. It is easy to see that a long, weedy clover plant has much less chance of life when competing for moisture with rank rye grass forced to luxuriance by the free use of manures, than normal clover has against ordinary rye grass on untreated land.

It was clearly shown last year that the disappearance of clover was not a question as between nitrate of soda and sulphate of ammonia; so far as injury to the aftermath goes, one is just as bad or as good as the other. On the whole sulphate did more harm on the plots, but only because, being applied some three weeks earlier, it began to act sooner.

It was also clearly indicated last season at some of the Durham stations, but more particularly at Cockle Park, where experiments were made on the subject, that an early application of a nitrogenous manure did much more injury to clover than a late dressing,* chiefly because an early dressing effects a greater increase in the first crop. The greater crop was not altogether the cause, however, for in some instances where the crops did not differ much in weight, it seemed that an early growth as distinguished from a heavy growth of rye-grass was responsible for injury.

Hints on the Use of Nitrate and Sulphate.—

It is unsafe to give advice on a subject which must so largely depend on circumstances as does the use of nitrogenous manures, but they are so profitable when properly employed and may do so much damage in unskilful hands that it seems desirable to give the following hints, if for no other reason than to draw the attention of farmers to some of the principles that regulate their application.

Heavy dressings† of nitrate of soda or of sulphate of ammonia will prove profitable on deep or moist land, where the main object is a heavy hay crop. If the aftermath is important, employ medium dressings only. When using heavy dressings apply early. Heavy applications (more especially of nitrate), late in the season are most objectionable, they rush up a weak, flag-leafed, top-heavy rye grass that gets laid with the first heavy shower; or if the season happens to be very dry the crop will be deficient. The safest way to employ heavy dressings is to apply one-half of the full quantity at intervals of 2-3 weeks. If this plan is adopted rather less manure may be used and the extra labour will be more than paid for.

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* In the case of Cockle Park "early" means April 1st to 10th, "late" May 1st to 7th. In earlier or later districts the terms would apply to somewhat different dates.

† By a "heavy dressing" is meant 1½ cwt. sulphate *or* 2 cwt. nitrate *or* ¾ cwt. sulphate and 1 cwt. nitrate. A medium dressing would be two-thirds and a light dressing one-third of these quantities.

Heavy dressings of nitrate or sulphate should not be used on light or thin land, or land out of condition, but if the farmer's only object is to grow rye grass, even light soils may be heavily dressed. Under such circumstances the manure should be applied a week or so later than on strong land, and not more than half of the total quantity should be given at one time.

When hay is grown for home use and not for the market it will be advisable to limit the use of nitrogenous manures to medium dressings on loams and clay soils, and to light dressings on sandy soils, for hay is one of those crops in which weight does not necessarily represent value and in which the residue (the clover root left in the soil) may bear a high proportion to the value of the fodder carted to the homestead.

Effects of Phosphates and Potash.—

The results produced by the use of 3½ cwt. superphosphate and ¾ cwt. muriate of potash are shown in Table C to have been of much less account than those due to the manures supplying nitrogen. Superphosphate has produced so small an average increase that its use has not been profitable (that is, if we consider the results on the first crop only). Muriate of potash has done a little better, but the increase is not striking.

TABLE C.

Compare Plots.	Increase per acre produced by	Cost of Manure.		Increase in Hay.	Profit or Loss (-) Hay at 60/-	
		s.	d.	Cwt.	s.	d.
5 & 1	3½ cwt. **super.** over unmanured land ...	10	6	2½	-3	0
7 & 4	Do. with nitrate and sulphate over nitrate of soda and sulphate of ammonia only	10	6	2	-4	6
9 & 4	Do. with sulphate, nitrate and muriate over nitrate sulphate and muriate only	10	6	½	-9	0
6 & 1	¾ cwt. muriate of **potash** over unmanured land	6	0	4	6	0
8 & 4	Do. with nitrate of soda and sulphate of ammonia over nitrate of soda and sulphate of ammonia only	6	0	2¾	2	3
9 & 4	Do. with sulphate, nitrate and super. over nitrate of soda, sulphate of ammonia and super	6	0	1¼	-2	3

What the above table shows to be true for the average of eight sets of plots Table IV. shows to be true for each centre. In no case was the first hay crop much increased by the use of superphosphate or of muriate of potash; at the same time when the stations were visited the colour of the crop showed that at some places one or other of these manures was making its influence felt. At Hall Farm, for example, the clover on Plot 5 was richer and more vigorous as the result of the dressing of superphosphate and at both Springs House, and Byers Garth, muriate distinctly improved the appearance of the herbage. At Cockle Park, at Newlands Haugh and to a lesser degree at some of the other centres the use of muriate and superphosphate freshened the aftermath.

On the whole, although we have had little evidence of the value of these manures in the experiments of the past two seasons, we have enough to show that a small quantity of potash say 2-3 cwt. of kainit or ¾ cwt. of muriate is likely to pay its way on most farms and that a dressing of 2 to 3 cwt. superphosphate will pay on some; but the problematical nature of the return makes it desirable that farmers should test these manures before adopting them as a part of the regular top-dressing for their hay land. It seems likely that better results might be got from autumn than from spring dressing. This point has been tested at Cockle Park without any very definite result being arrived at. Arrangements are being made for further trials at new centres next season.

Summary.—

(1) Experiments on the manuring of seeds hay were conducted at nine centres in 1901. At each station the plots were in duplicate series.

(2) Sulphate of ammonia gave better crops than nitrate of soda in 1901, in 1900 the reverse was the case. These results are partly explained by the character of season 1901 (see p. 44).

(3) In both years a manure, consisting partly of nitrate and partly of sulphate, gave better results than either used separately. Except when soil or price distinctly indicate the one or the other as most suitable, farmers should use both for top-dressing grass.

(4) Hints for the use of nitrate of soda and sulphate of ammonia are given on p. 47.

(5) In such a season as 1901 the aftermath is very liable to injury from the free use of these nitrogenous manures. The clover may be killed out.

(6) Spring applications of phosphates and potash produced little effect on the hay crop, but slightly improved the appearance of the aftermath at several stations.

ROTATION EXPERIMENTS AT PEEPY AND WHITEFIELD.

(TABLES V., VI. and VII.).

These experiments have now been in progress for eight years on the farms of Mr. J. Knox Lyal, at Peepy, Stocksfield-on-Tyne, and of Mr. John Angus, at Whitefield, Morpeth. The oat crop harvested in 1901 completed the second four-course rotation. The crops in the case of each rotation were:—1, roots; 2, barley; 3, hay (mixed rye grass and clover) twice cut; 4, oats. The soil at Peepy consists of a fertile and moderately heavy loam resting on Boulder clay; at Whitefield, of a fertile sandy loam on gravel. When taken up for experimental purposes both fields were in a high state of cultivation, the results of liberal farming and careful tillage. It is important to remember when considering the results of the rotation experiments at Peepy and Whitefield that these stations were selected as typical of well-farmed land in Northumberland, and not, as in the case of the County Farm at Cockle Park, because of the poor and exhausted state of the soil.

The scheme of manuring was altered at the end of the first rotation, and before discussing the results of the experiment it will be necessary to indicate the general plan of treatment. A detailed statement of the manures applied for the first rotation has been given in the Sixth Annual Report (See Table facing p. 8), and the manures used for the second rotation will be found in Table V., p. 130 of this report. A summary contrasting the treatment for each rotation is given below. Contractions have been used in order to economise space. (For explanations see the footnote.)

TABLE A*

Plot.	Manuring for First Rotation, 1894-97.	Manuring for Second Rotation, 1898-1901.	Plot.
1	12 D.	12 D.	1
2	Do. + 5¼ A.	Do. + 5½ super + 2 F.M.	2
3	Do. + 10½ A.	Do. + 11 „ + 4 „	3
4	Do. + 5¼ A.†	Do. + 5½ „ + 2 „ †	4
5	6 + 6 D. + 5¼ A.	6 + 6 D. + 5½ „ + 2 „	5
6	6 D. + 5¼ A.	6 D. + 5½ „ + 2 „	6
7	9 D. + 5¼ A.	9 D. + 5½ „ + 2 „	7
8	15 D. + 5¼ A.	15 D. + 5½ „ + 2 „	8
9	12 D. + 2⅝ A.	12 D. + 2¾ „ + 1 „	9
10	No manure.	No manure.	10
10A		12 D.	10A
11	B. M., etc.	Do. + 3¾ B.M.	11
12	D. B., etc.	Do. + 5 D.B.	12
13	Super, etc.	Do. + 5½ super + 2 F.M.	13
14	Slag, etc.	Do. + 4¼ slag + 2 „	14
15	10½ A.	Do. 5½ super + 2 „ + 4 K.	15
16	Do. omitting kainit.	Do. 5½ „ + 2 „ + 4 „ †	16
17	5¼ A.	Do. 5½ „ + 2 „ + 4 „ †	17
18	Twice as much kainit and three times as much of other manures as plot 17.	Do. 5½ „ + 2 „ + 1 „ †	18
19	... ...	12 horse dung + artifs. as for Plot 18.	19
20	... ...	24 corporation manure do.	20

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* In this table D. stands for dung; the numbers 6, 12, etc., indicate the weight in tons per acre applied; 6 + 6 means 6 tons to roots and 6 tons to seeds; A. stands for a mixed artificial manure; B.M. for bone meal; D.B. for dissolved bones; F.M. for fish meal; the numbers 5, 7, etc., show the weight in cwt. per acre of the artificial manures. In the first rotation, Plots 12 and 13 received 83 lbs. phos. acid and 17·8 lbs. nitrogen per acre, the former in 5 cwt. dissolved bones, the latter in 4⅛ cwt. super and 2 cwt. fish meal. Plots 11 and 14 received 100 lbs. phos. acid and 17·8 lbs. nitrogen the former in 4¼ cwt. bone meal, and the latter in 4⅝ cwt. slag and 2 cwt. fish meal. All four plots got in addition 17·3 lbs. nitrogen in sulphate of ammonia and 55 lbs. potash in 4 cwt. kainit per acre. Plot 15 received ¼th of the combined dressings of plots 11, 12, 13 and 14, and this forms the mixture called A. in the table. The contractions used in the case of the second rotation will be readily understood. Plots 11, 12, 13 and 14 received 95 lbs. phos. acid and 17½ lbs. nitrogen per acre. All plots except 10 received dung for the second rotation. A few plots only received kainit "K." All the plots received ½ cwt. nitrate of soda for the seeds.

† In plots marked thus the artificial manures were partly applied to the root crop and partly to other crops. In all other cases the artificials were applied to the root crop only.

It will be observed from the above table that the chief differences in the manuring of the two rotations were (1) that in the first rotation half only of the plots received farmyard manure, whereas this was applied to all except the untreated plot in the second rotation; and (2) that superphosphate and fish meal, which had proved the most successful artificial mixture in the first rotation, were largely used in the second rotation in place of more complex mixtures.

Before discussing the results of the experiments in this second rotation some of the more important facts brought out in the first four years may be recalled. The following summary has been taken from Dr. Somerville's report for 1897:—

(1) Bone meal has borne out its reputation as a slow acting manure serviceable in certain circumstances.

(2) Dissolved bones had a good effect on the first crop, but was disappointing for subsequent crops.

(3) Superphosphate with fish meal to supply nitrogen did well, and better than dissolved bones.

(4) Slag did not do quite so well as superphosphate.

(5) A mixture of these phosphates did well at Peepy, but not at Whitefield.

(6) Heavy dressings of artificials (13 or 14 cwt. per acre) used without farmyard manure and all applied to the turnips have paid slightly better than smaller dressings.

(7) Large dressings of artificials applied to the roots have but little influence on the third and fourth crops of the rotation.

(8) Potash is generally necessary in a mixture of artificials where farmyard manure is not used, and it is most likely that this substance may be profitably applied to the hay crop even when the previous root crop has received dung.

(9) In general it is best to cover as large an area as possible with the dung produced upon the farm;

a light application to a certain area will give better results than, for example, a double dressing used on half the ground.

(10) The application of large quantities of manure to the root crop, does not render the manuring of the subsequent crops unnecessary.

The Oat Crop of 1901.—

Three of the crops of the second rotation have already been briefly noticed in the reports of the Department,* and before discussing the general results of the experiment it will be convenient to give a few notes on the oat crop of the past season. The crop at Peepy was a very good one. It was rather short in the straw, but full of corn. Very considerable differences occurred in the growing crop. The differences in appearance were indeed greater than the figures in Table V. indicate. Starting at the first plot there was a gradual improvement up to the 4th, and then in the 5th a very marked change, showing clearly that the crop was deriving much benefit from the six tons of dung applied to the seeds. A part of this benefit was doubtless directly due to the residue of the dung, and a part to the influence of the residue of the fine clover crop which this particular plot grew last year. On Plot 6 there was a sharp drop showing plainly how much the land suffered from the want of a full dressing of dung. On Plot 8 again the advantage to be derived from a plentiful supply of farmyard manure was as plainly visible. The crop on Plot 10, although thin and short in the straw, was wonderfully good for land that has been twelve years without manure. Of the plots in the latter part of the experiment, No. 16, which received a top-dressing, was distinctly earlier than the others. The crops on 17, 19 and 20 were inferior, but the fish meal applied to Plot 18 much improved this plot.

On the whole the crop at Whitefield was very similar to that at Peepy, but on this farm Plots 1 and 2 were unfortunately injured by birds. The oat grown was "Tartar King," which ripens early, and Plots 1 and 2 were not only somewhat earlier than the others, but were close to a hedge, and in this way suffered. As at Peepy, the crops on Plots on 5 and 8 were very good, and the contrast between Plots 5 and 6 was sharp. Plots 11 to 20 at Whitefield were on the whole very uniform and showed less variation than they did at Peepy. From the appearance of the growing crop and from the figures given on page 131, it is apparent that in the dry season of 1901 the oat crop was chiefly influenced by the amount of farmyard manure that had been used for the previous crops. The different artificials produced but little effect. The top-dressings of fish meal improved the appearance and made the crops earlier on the strong soil at Peepy, and rather later than the neighbouring crops on the light soil at Whitefield.

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* See Annual Reports for 1898, pp. 11, 31 ; 1899, p. 70, and 1900, p. 66.

Several of the Whitefield plots have been injured by a pitfall, and when harvesting the oat crop it was found necessary to weigh the crop from ⅙ of an acre in each case and not from the whole ¼-acre plot. The yield of crop—corn and straw—for 1901 will be found in Table V., page 131.

Method of presenting Results.—

Particulars respecting the weight of crop grown on the experimental plots in the years 1898-99-1900 have already been printed, and are not given in the Appendix to this Report, but Table VI. contains the value of each crop grown on Peepy and Whitefield, and Table VII. the average value of the crops grown at the two stations. The produce of each plot having been valued at an uniform rate, the figures in these tables form a basis for comparison.

The crops were valued as follows:—

	1894-97. Shillings.	1898-01. Shillings.
Swedes per ton...	8	8
Barley per qr. of 448 lbs.	25	25
Oats per qr. of 336 lbs.	18	20
Barley straw per ton ...	30	25
Oat straw ,,	35	35
Hay, 1st cut ,,	60	60
Do. 2nd cut ,,	45	60

The Unmanured Plot.—

Before noticing effects that have been produced as the results of manuring, it will be interesting to glance at changes produced by the seasons and by withholding manure altogether. The rates on the whole were slightly higher in the second than in the first rotation; but were so nearly alike, that in the following table the differences have been neglected. The table shows the shrinkage in the value of the produce of the unmanured plot in the second four years, and also the shrinkage in the average value of the produce of the seven plots Nos. 3 to 9. These seven plots were upon very uniform soil, the treatment in the second rotation was rather more liberal than in the first, and the falling off in value must be attributed to unfavourable seasons. A comparison of the falling off in the manured and unmanured plots enables us to form some idea of the rate at which the soil of the latter is undergoing exhaustion.

TABLE B.

	Value of produce on unmanured plots.				Average value of produce on 7 manured plots 3-9.				Fall in value of produce in second rotation as compared with first.			
	1894-97.		1898-01.		1894-97.		1898-01.		Unmanured Plots.		Manured Plots.	
	£	s.	£	s.	£	s.	£	s.	£	s.	£	s.
Peepy	33	1	24	4	38	17	34	10	8	16	4	7
Whitefield ...	24	7	21	12	36	18	33	15	2	15	3	3
Average ...	28	14	22	19	37	17	34	2	5	15	3	15

From the above table it will be seen that even on the manured plots there has been much less crop during the past four years than in the first four. This falling off was chiefly due to the less favourable character of seasons 1898 for roots and 1901 for oats, than their predecessors 1894 and 1897. If these plots on Peepy and Whitefield represent the general state of affairs on north country farms during the past four years, hey indicate a considerable shrinkage in out-turn as compared vith the previous four. They indicate, too, how a farmer's apital rises and falls as one course follows another, and show iow quickly even a short run of bad seasons must reduce a apital which in all cases is very small as compared with the ross value of the produce.

At Whitefield there has been apparently very little falling ff in the unmanured plot during the second rotation as comared with the first. There has actually been a fall of £2 15s., ut this fall, which is equal to 11 per cent., may be assumed to e chiefly due to season, for on the manured plots the fall was early as great, viz., 8 per cent. The light dressing of nitrate f soda used for the seeds would have been of some assistance o Plot 10 in the second rotation, and taking its effect into ccount we may conclude that at Whitefield there was a great alling off in the fertility of the soil during the first four years fter manure was withheld, but that the falling off in the econd four years was comparatively trifling. Whitefield epresents a type of soil that loses "condition" very quickly.

At Peepy the falling off during the first rotation was not early so great as at Whitefield, but during the second course lot 10 at this station has fallen off much more than the correponding plot at Whitefield. In other words the effects of tarvation are more gradual at Peepy than at Whitefield, and he soil does not lose condition so quickly.

he Effect of increasing the Quantity of Farmyard Manure.—

Plots 6, 7, 2, 5 and 8 received respectively 6, 9, 12, 12 and 15 tons of farmyard manure in each rotation. The manure was in all cases applied to the root crop except on Plot 5, where half was reserved for the seeds. The following statement shows the total value of the crops resulting from the manurial treatment:—

TABLE C.—SHOWING THE RESULTS PRODUCED BY SMALL AND LARGE DRESSINGS OF F. Y. M.*

Perpy (Loam) Figures per Acre.

Plot.	Tons of Dung.		Gross Value of Crops.					
	1894.	1898.	1894-97.		1898-01.		1894-01.	
			£	s	£	s.	£	s.
6	6	6	35	18	31	16	67	14
7	9	9	38	8	33	3	71	11
2	12	12	36	11	33	13	70	4
5	6 + 6	6 + 6	38	17	34	17	73	14
8	15	15	39	16	36	19	76	15
	Average of Plots 6 and 7 ...		37	3	32	9		
	Average of Plots 5 and 8 ...		39	6	35	18		
	Difference ...		2	3	3	9		

Whitefield (Light Soil).

Plot.	Tons of Dung.		Gross Value of Crops.					
	1894.	1898.	1894-97.		1898-01.		1894-01.	
			£	s.	£	s.	£	s.
6	6	6	33	18	31	0	64	18
7	9	9	34	15	33	1	67	16
2	12	12	37	16	29	8	67	4
5	6 + 6	6 + 6	36	19	35		72	2
8	15	15	38	5	35	18	74	3
	Average of Plots 6 and 7 ...		34	6	32	0		
	Average of Plots 5 and 8 ...		37	12	35	10		
	Difference ...		3	6	3	10		

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* All plots received in addition to F. Y. Manure 5 cwt. Artifs. in 1894 and 7½ cwt. in 1898. F. Y. M. applied to Roots, except on Plot 5, where half wa used for Seeds.

Plot 2 is somewhat abnormal on both Peepy and Whitefield, nd has all along produced less than it should have done; passng over the results obtained from it, we note that in the other ases each increase in the quantity of farmyard manure has een followed by an increase in the value of the crop. As a esult of dividing the 12 tons of dung between roots and seeds he crops have probably produced a rather higher return than therwise they would have done, but a comparison of the results btained from Plots 5, 7 and 9 will show that the gross value f the crops produced by Plot 5 can be very little more than night be expected from 12 tons of manure applied for the oot crop.

When the results obtained on the two lightly manured lots 6 and 7 are compared with those obtained from a more iberal use of manure on Plots 5 and 8 it is seen that the larger ressing has increased the value of the first four crops at Peepy by 43s. and the second four by 69s. per acre. At Whitefield the orresponding figures were 66s. and 70s. per acre. At Peepy there is thus an indication of a considerable unexhausted value at the end of the first rotation. At Whitefield the effects of the liberal manuring seem to be chiefly confined to the rotation in which the manure was used.

The return per ton of dung is highly satisfactory, and indicates the desirability of working up the stock of dung produced by a farm so as to be able to use full dressings. It has already been remarked, p. 54, that the return per ton of dung is higher with light than with heavy dressings, and for this reason under ordinary circumstances as large an area as possible should be covered with the dung produced upon a farm; but if a plentiful supply of dung (say 15 tons per acre of fallow) can be got together, our experiences at Peepy and Whitefield show that the crops will pay well for it.

Should all the Dung be applied to the Fallow?—

The net advantage which has resulted from applying half of a dressing of 12 tons of dung to the roots and half to the seeds has been very trifling (compare Plots 7, 5, 8 and 9); but inspection of the plots clearly showed that both clover and oats were much benefited by the 6 tons of dung applied to the former, and in a season unfavourable to clover, it is likely that the presence or absence of dung would on many farms determine whether the clover in the seeds hay was to be a fair crop or a failure. It seems probable that if a farmer in the North of England has 15 tons of dung per acre of root-break to apply, it would pay him better to give 10 tons to the roots and 5 tons to the seeds than to use the whole quantity on the former crop. With 12 tons at his disposal, it is unlikely that it would be worth his while to divide the dressing.

Unexhausted Value of Farmyard Manure.—

The treatment of several of the plots at Peepy and Whitefield enables us to estimate the effects produced by a dressing of dung, applied to roots in 1894, upon the four crops of the next rotation grown between 1898 and 1901. The plots on the left-hand side of Table D below received dung in 1894 and again in 1898; the plots on the right-hand side received dung in 1898 only. All the plots received dressings of artificials in 1894, the dressings given to Plots 15, etc. being twice as great as to Plots 2, etc. Further, in 1898 Plots 15 and 17 received 4 cwt. kainit, which the corresponding plots on the other side did not have. There is evidence, however, that these differences in the artificial dressings can have produced little or no effect on the crops of 1898-1901. We may, therefore, leave them out of account for the present. The plots contrasted were originally of a very uniform character, for the whole of the land chosen for experiment was very uniform, and the results from those plots which have shown themselves to be in any way abnormal have been excluded. In all cases the dressings of dung amounted to 12 tons per acre, except on Plots 7 and 8, where 9 and 15 tons respectively were applied.

Table D shows the benefit which the crops of 1898-1901 have derived from the dung applied in 1894.

TABLE D.

Plot.	Gross Value per Acre of Crops of 1898-01.						
	Plots dunged 1894 and 1898.			Plots dunged 1898 only.			
	Peepy.	Whitefield	Average.	Plot.	Peepy.	Whitefield.	Average.
	£ s.	£ s.	£ s.		£ s.	£ s.	£ s.
2	33 13	—	—	15	34 3	34 1	34 2
4	36 6	33 15	35 1	16	33 14	35 2	34 8
*7	33 3	33 1	33 2	13	33 2	34 2	33 12
*8	36 19	35 18	36 9	14	34 1	33 4	33 13
9	32 17	34 19	33 18	17	32 12	33 8	33 0
Average	34 12	†34 3	†34 12	Average	33 10	33 19½	33 16
Balance in favour of Plots twice dunged ...					1 2	0 3/6	

The result of a comparison of 10 ¼-acre plots on Peepy and of 9 plots on Whitefield is that on the former farm the unexhausted residue of 12 tons of dung applied in 1894 was sufficient to increase the value of the four crops grown between the fifth and eighth year by 5s. 6d. per acre per annum, on the latter farm the corresponding increase was only 10d. per acre. These figures indicate that on the strong soil at Peepy there was in 1898 a very considerable residue of the dung applied in 1894, but that on the sandy soil at Whitefield the effects of the manure applied in 1894 were almost exhausted by the four crops of the first rotation.

In connection with the values deduced above, two points must be remembered; the first is that the figures are less than the actual values of the dung residue by the sum that represents the effect produced by the artificials above referred to; it is believed that this sum is a very small one, so that the productive value of the dung residue is but very slightly underestimated. The second point is of more importance, it is that the values in question represent the effects produced by dung on well-farmed and liberally manured land, and are such as may actually be looked for in farm practice. If instead of

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* To these plots 9 and 15 tons of Dung applied respectively.
† Average of four plots.

estimating the residual value in the above manner, manure had been withheld in the second rotation and the land had been run down in condition, the dung residue would have shown a much higher value, but a value that could not be realized under ordinary farming conditions.

The effect produced by the residue of an application of 12 tons of farmyard manure is also shown by a comparison of Plots 1 and 10A at Peepy. (At Whitefield the crop on the former plot was injured by birds.) Plot 1, which received dung in 1894 and 1898, yielded £32 11s. worth of crop for 1898-1901; Plot 10A, which received dung in 1898, only yielded £31 13s. worth of crop for 1898-1901. The balance in favour of land twice manured was 18s. per acre.

Effects of Artificial Manures.—

The effects produced by the use of artificial manures along with dung during the first four years, were shown by Dr. Somerville to have been erratic, "slight inequalities of soil being able to influence the yield to a greater extent than artificials used as supplementary dressings to dung." In the case of Whitefield, the figures for the second rotation are again erratic, but at Peepy they are consistent, and, as will be seen in the following Table, show a small increase for the artificial dressings.

TABLE E.

Plot.	Treatment. 12 tons Dung and	Cost of Artificials.	Value of				Total Value of Four Crops.		Increase due to Artificials.	Profit or Loss.
			Roots and Hay.		Barley and Oats.					
			£	s.	£	s.	£	s.	s.	
1	No Artificials ...	—	15	0	17	11	32	11	—	—
9	3¾ cwt. Artificials	16/3	14	10	18	7	32	17	6	–10/3
2	7½ " "	32/6	15	19	17	4	33	13	22	–10/6
3	15 " "	65/-	16	11	19	2	35	13	62	–3
4	7½ " " distributed.	32/6	16	10	19	16	36	6	75	42/6

Where artificial manures were applied with dung for the root crop (Plots 9, 2 and 3) they have not paid, but on Plot 4, where a portion of the artificial dressing was applied to the barley and seeds, there was a profit. The total dressing for Plot 4 was the same as for Plot 2, viz., 5¾ cwt. superphosphate and 2 cwt. fish meal. On the former plot half of the superphosphate was applied to the roots and half to the seeds, but neither the seeds nor the following corn crop was distinctly benefited. On the other hand the result of using fish meal for barley after roots (carted off the land) was satisfactory. At both stations there was a marked increase in the corn and a small increase in the straw. The use of 32s. 6d. worth of artificials on Plot 4 at Peepy is seen in Table E above, to have resulted in a profit of 42s. 6d. per acre in four years. Owing to the irregular results obtained from Plots 1 and 2 at Whitefield the profits shown by Plot 4 at that station are too high. It is probable, however, that the artificials paid quite as well as on Peepy.

On several of the plots (see Table VI.) the effect of distributing superphosphate and kainit over the rotation, instead of applying them to the root crop, has been tested, but in no case has there been any benefit from doing so; neither has the use of fish meal for seeds hay been profitable.

The best Artificial Manure.—

Equivalent quantities of bone meal, dissolved bones, superphosphate and fish meal and slag and fish meal were used on Plots 11, 12, 13 and 14. Table F shows the results.

TABLE F.

Plot.	Treatment. 12 Tons Dung and	Value of Four Crops.					
		Peepy.		Whitefield.		Average.	
		£	s.	£	s.	£	s.
11	3¾ cwt. Bone Meal	32	17	31	15	32	6
12	5 cwt. Dissolved Bones ...	32	12	32	16	32	14
13	5½ cwt. Super + 2 cwt. Fish Meal	33	2	34	2	33	12
14	4½ cwt. Slag + 2 cwt. Fish Meal	34	1	33	4	33	13
15	Same as Plot 13 with 4 cwt. Kainit added	34	3	34	1	34	2
16	Same as Plot 15, Manures distributed	33	14	35	2	34	8

Superphosphate and slag have practically yielded the same returns, and these two manures with fish meal to supply nitrogen, have proved better than the bone manures used on Plots 11 and 12.

Horse Dung and Corporation Manure.—

A dressing of 12 tons horse dung* has on the whole produced slightly better results than the same weight of ordinary farmyard dung at both stations, whereas an application of 24 tons of Corporation manure has not done quite as well. Plots 19 and 20, to which these manures were applied, should have received the same artificials as Plot 18, but through an error they did not receive 1 cwt. of fish meal which they should have had for the oat crop. As a result the oat crop on Plots 19 and 20 was probably worse by some 10s. per acre than it would have been. This sum should be added to the value of the crops grown on Plots 19 and 20 when comparing them with Plot 18. (See Tables V. and VI.) The inferiority of Corporation manure to dung as a clover-producing manure was noticeable at both stations, and was especially well marked on the light soil of Whitefield.

Summary.—

(1) A rotation experiment has been carried on at the farms of Peepy and Whitefield for eight years, the results of the second 4-course rotation are given above.

(2) The treatment in the second rotation differed somewhat from that in the first, for details see p. 52.

(3) The seasons 1898-1901 were less favourable than 1894-1897 and there is a considerable shrinkage in the gross value of the crops.

(4) The unmanured plot on the light soil of Whitefield deteriorated greatly between 1894 and 1897, but the further deterioration has not been marked. On the heavier soil at Peepy the deterioration during the first rotation was less

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* 12 tons rotted dung at Whitefield, 15 tons fresh at Peepy.

and during the second rotation greater than at Whitefield. The soil of the latter responds quickly to either generous or niggardly treatment, the soil of the former does not. Except in the rate at which they act, the effects of manures have been similar on both farms.

(5) Although the return per ton of dung was less for large than for small dressings both stations paid well for a full application of farmyard manure.

(6) With 15 tons dung available per acre of fallow, it will often pay to apply a portion only to the fallow crop and the remainder to the seeds. When 10 to 12 tons are available it will not usually be worth while to divide the dressing.

(7) A dressing of 12 tons per acre of dung applied to the sandy soil at Whitefield in 1894 produced little or no increase in the crops grown between 1898 and 1901. On loam at Peepy the residue of 12 tons dung applied in 1894 increased the value of the crops grown between 1898 and 1901 by 22s. per acre.

If we assume that there was no further residue after the harvest of 1901, we see that in the spring of 1898 the unexhausted value of each ton of dung applied to the crop of 1894 would be 1s. 10d. The conditions under which this value has been found are referred to on p. 61.

(8) Artificials applied with dung for roots have not done much good at Peepy, but artificials used as on Plot 4 (2¾ cwt. superphosphate to the roots and the seeds and 2 cwt. fish meal to barley) have been profitable. At Whitefield, owing to the condition of Plots 1 and 2, conclusions cannot be drawn from the figures in Table VI., but from the appearance of the later crops of the rotation it seems likely that artificials paid well.

ROTATION EXPERIMENT AT ROSE BANK, DALSTON.

(TABLE VIII.)

Between the years 1896 and 1901 a rotation experiment was carried out at the farm of Rose Bank, Dalston, on a field placed at the disposal of the College by Mr. R. Tinniswood. The area of the station was 6 acres; it was divided into 24 ¼-acre plots. The soil* consisted of a poor loam of medium texture, representative of the ordinary moorland of the district. Beneath a surface covering of 8 or 9 inches of soil there was a stiff impervious pan, which is characteristic of this class of land. The portion of the field on which the first 18 plots were situated had been broken up from old poor pasture about 1892, the remaining 6 plots had been a few years longer under cultivation. The soil on the whole was found to be very uniform, and it will be remembered that the experiment yielded instructive results. A summary of these results given at page 64 of the Report for last year showed that this soil responded in a remarkable way to artificials, especially to mixtures of manure containing potash; that farmyard manure produced relatively poorer results than at most of our other centres, and that neither in its immediate effect nor in its lasting power did it display any superiority over artificial mixtures. The most interesting result brought out by the experiment was that on this land, which responded so freely to the action of artificial manures, it paid better to apply the whole of the artificial dressings to the root crop than to apply a portion only to the root crop and to spread the remainder over the subsequent crops of the rotation.

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* For composition see p. 148.

Mr. Tinniswood has again kindly consented to place his land at the disposal of the County Council and the College, and a second rotation experiment was begun last season. The objects of this second experiment are as follows; the references are to the plots in Table VIII.

(1) To contrast the effects of applying all the manure to roots, and of spreading a portion or all over the other crops of the rotation. Compare Plots 2, 3; 5, 6; 9, 10; 13, 14; 16, 17.

(2) To compare the effects of slow acting and of quick acting manures (1) when all applied to roots, (2) when partly distributed. Plots 5, 9; 13, 16; 8, 10; 15, 17.

(3) To compare the effects of a potash manure when used without and with varying dressings of dung on a soil naturally deficient in potash. Plots 1, 2, 3; 6, 7; 17, 18.

(4) To ascertain what residue still remains of the large dressings of artificial manures applied to Plots 19, 20 and 21 during the first rotation. The treatment of Plots 20 and 21 was on the whole similar during the first rotation. The former will now receive dressings of nitrate of soda for the corn and hay crops of the second rotation, so as to test the power of nitrate to "extract" manurial residues.

(5) To measure the effect on the subsequent crops, of feeding 5 cwt. per acre linseed cake to sheep consuming roots and hay. Plots 22, 23, 24.

In laying out the plots for the second experiment due regard was, of course, paid to the previous treatment so that the results which will be obtained from the plots in the second rotation will not, for the purpose of comparison, be much affected by the treatment given to them during the first rotation. At the same time when the complete figures for the second rotation are available it will be necessary to study them in the light of the manuring and results of the first rotation as given in detail on p. 196 of the Ninth Annual Report.

The root crop of the past season was a very satisfactory one as will be seen from the detailed yield given at page 134, but the first four plots and to a small extent the fifth and sixth had suffered from the ravages of rooks.* The plots were each ¼-acre and half of the roots were lifted for weighing under the supervision of Mr. Lawrence.

In calculating the yield per acre in Table VIII. the blanks have been allowed for, and in the case of the first four plots as the area from which the crop was weighed was considerably less than on the other plots, the results are proportionately less satisfactory, but the even character of the soil and of the crop lifted for weighing was sufficient guarantee that the method of estimating was reliable and that the results can be but little different from what they would have been if the rooks had left the field undisturbed.

The following notes on the first crop of the second rotation will deal with a few of the objects of the experiments only.

The Unmanured Plot.—

The root crop here was most satisfactory showing both extreme natural poverty and also evenness of quality. The turnip crop came with perfect regularity but died off from want of nourishment during the season, and when the crop was lifted a few stunted roots only remained at one end of the plot. The contrast between the bare soil of Plot 11 and the fine, vigorous, uniform crops on the immediately adjoining Plots, Nos. 10 and 12, was most striking.

Mr. Collins' analysis given on page 148 shows the soil to be markedly deficient in available phosphates and potash.

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* Out of a total of 774 yards of drill measured, the following lengths were blank:—Plot 1, 442 yards; Plot 2, 270 yards; Plot 3, 314 yards; Plot 4, 116 yards: Plot 5, 17 yards; Plot 6, 38 yards.

Cereals and Roots compared.—

The very different requirements as regards soluble phosphates of cereal crops and root crops is well illustrated by this experiment. The root crop on the unmanured plot was an absolute failure; as there is direct proof that this was not caused by the absence of potash, the failure must have been due to the want of available phosphates, for the absence of a nitrogenous manure, though it injures, never absolutely destroys a root crop (unless it be indirectly when insect pests attack enfeebled plants).

In Table A the behaviour of the oat crop and of the root crop on unmanured land and on land manured with phosphates and nitrogen is contrasted.

TABLE A.

Plot.	Treatment.	Percentage of "citric acid soluble" phosphoric acid in surface soil.	Average per acre, oat crops of 1897 and 1900.		Swedes, 1901.	
			Corn.	Straw.		
			Bushels.	Cwt.	T.	C.
1	100 lbs. phosphoric acid and 35 lbs. nitrogen per acre in bone meal, etc., in 1901, and similar treatment in 1896	·009	45⅞	27½	19	7
11	No manure	·008	44⅝	20¾	1	5
	Increase due to manure ...	—	1¼	6¾	18	2

The oat crop has made a moderately successful fight for existence on the unmanured land, the Swedish turnip has been an absolute failure.

Dr. Dyer, in his paper on the "Wheat Soils of Rothamsted,"* states the probable limit denoting phosphatic deficiency for cereals to be between ·01 and ·03 per cent. of citric-acid-soluble phosphoric acid in the surface soil, and adds that for "root crops, more especially turnips, the limits would probably be higher." In the cooler and less forcing climate

* Phil. Trans. Roy. Soc. Lond., vol. 194, p. 269.

of the north of England, the oat crop would seem to grow fairly well in a soil containing less than ·01 per cent., but the root crop does not grow at all.

Effect of Farmyard Manure.

Nine tons of dung per acre were given to Plots 4, 6, 19, 20 and 21. Plot 19, for some reason which cannot be explained, has always produced less crop than its treatment would warrant. It looks exactly the same as its neighbours, but must be naturally inferior and need not be further referred to here. As compared with Plots 4 and 6 Plots 20 and 21 were very liberally dealt with in the first rotation and the final oat crop on the two latter plots was better by 13 bushels of grain and 3 cwt. of straw per acre than on the former, but the root crops on Plots 4 and 6 were quite as good as, indeed rather better than, on Plots 20 and 21. (Compare remarks on pp. 31-34 Seventh Annual Report.)

The average crop on Plots 4 and 6 weighed 17 tons 18½ cwt., on Plots 12 and 14, which received 15 tons dung, the crop was 19 tons 2½ cwt. The increase here may be assumed to be due to the extra quantity of dung used in 1901, the difference in the treatment in 1896 can scarcely be held to have affected the result. As might have been anticipated no advantage has been derived from the addition of ½ cwt. muriate of potash to dung on Plots 7 and 18, although this manure proved most useful as an addition to an artificial mixture (Plots 1 and 2).

Artificial Manures.

It has already been shown by the results in the first rotation that the Rose Bank soil is well adapted for artificial manures; last season they again proved satisfactory on Plots 1 and 2. On the portion of Plot 1 weighed the out-turn was at the rate of 19 tons 7 cwt. per acre, and where 1 cwt. of muriate of potash was added on Plot 2, the crop was 21 tons

16 cwt. A reduction of the artificial mixture by one-third reduced the crop by nearly one-fourth.

The effect of using artificial manures in addition to dung is shown in Table B.

TABLE B.

Average of plot.	Treatment per acre.	Yield per acre.		Increase over dung plots.	
		Tons.	Cwt.	Tons.	Cwt.
4, 6, 12 and 14	Dung alone	18	10½	—	
5 and 13	Dung, + about 1 cwt. sulphate of ammonia, 2 cwt. bone meal, 1½ cwt. dissolved bones, and 1½ cwt. superphosphate	20	13½	2	3
9 and 16	Do., + about 1⅛ cwt. sulphate of ammonia, 3 cwt. dissolved bones and 3 cwt. superphosphate	21	2	2	9¼
10 and 17	Do., + about ⅝ cwt. sulphate of ammonia, 1½ cwt. dissolved bones, and 1½ cwt. superphosphate	18	19¼	0	9
8 and 15	Do., + ⅜ cwt. sulphate of ammonia and 2 cwt. bone meal	18	19¼	0	9

The larger artificial dressings have produced a substantial, but not as yet a profitable increase. The smaller dressings have not much improved the crop. Plot 17 yielded 2 tons less than Plot 10 in spite of the larger dressings of dung and like Plots 18 and 19 appears to be scarcely as good as the others.

The produce of the remaining plots calls for no remark at present. The crops were in part consumed by sheep getting hay, or hay and clover and the first results of the special treatment will be seen on the corn crop of 1902.

Summary.—

(1) This experiment is a continuation of a previous rotation experiment fully described in last year's Report.

(2) Attention is drawn to the striking contrast between the manurial requirements of roots and cereals.

(3) This soil is shown to be deficient in "available" potash both by analysis and by the results of field trials; but though potash is effective as a constituent of an artificial mixture, the addition of muriate of potash to a dressing of 9 tons per acre of dung has not increased the root crop.

(4) The soil at Rose Bank responds readily to artificials, but where these have been used with dung for the root crop they have not left a profit. As was the case in the rotation which finished in 1900, there will doubtless be a substantial profit from the use of the artificials when the remaining crops of the second rotation have been harvested, and the effects on all of them have been ascertained.

ROTATION EXPERIMENT AT KIMBLESWORTH.

(TABLE IX.)

A rotation experiment conducted by Mr. George Liddell at Kimblesworth was described at page 37 of last year's Report. A second experiment on the same piece of ground was begun with the root crop of 1901. This experiment, like the last, will continue for five years. The crops will be the same with the exception that for the first rotation potatoes formed the root crop, and in the second swedes have been substituted.

The first four plots occupied by the experiment in last rotation were not of a uniform character. They have, therefore, been omitted on this occasion, and the experiment begins with Plot 5. The old numbers have been retained, however, so that the previous history of each plot may be seen by referring to the Report for 1900. The main objects of the present experiment are, first, to test the value of distributing artificial manures over the rotation instead of applying them all to the root crop; second, to discover what influences the residues of the previous manuring may exercise upon the crops of this rotation.

The soil at Kimblesworth consists of a medium loam, it is clean and in first rate condition for experimental purposes. The composition of this soil will be found at page 148. It will there be noticed that the percentages of "citric-acid-soluble" potash and phosphoric acid are very low and that the texture is somewhat more open and sandy than that of the soil at Rose Bank, Dalston.

The results obtained with the swede crop will be found in detail in Table IX. The crop was a good one, and in every way satisfactory from the experimental standpoint. The unmanured land proved very poor, and, as at Rose Bank, the contrast between the untreated plot and its neighbours was most marked. At Kimblesworth the unmanured plot would have been better had not the diamond-back moth visited the field and done considerable injury to the weak plants. The plots were twice inspected, and from the appearance of the crop it was anticipated that those plots which received artificials with farmyard manure would be very much better than those that received farmyard manure only. The full dressings of artificials applied to Plot 13 materially improved the look of the crop, but it will be noticed that the actual increase in weight was not very striking. The following are the average crops produced by dung alone and by dung with artificials:—

	Tons.	cwt.
12 tons dung (Plots 16, 17 and 18)	18	18½
12 tons dung + 3½ cwt. of artificials (Plots 9 and 11) ...	20	2½
12 tons dung + 7 cwt. of artificials (Plots 13 and 14) ...	20	3½
18 tons dung (Plots 5, 6 and 8)	20	¼
18 tons dung + artificials (Plot 7)	22	4

The smaller dressing of artificials when used with 12 tons dung has increased the crop by 24 cwt., at the unprofitable cost of 15s. The heavier dressing has scarcely produced any further increase on Plots 13 and 14, but on Plot 7, when used to supplement 18 tons dung, there was a distinct improvement in both appearance and weight. Although from the appearance of the growing crop both in July and in October a profit was expected, the light manures have not left an immediate profit. If the Kimblesworth experiment turns out as the others have done, however, a direct profit from the use of the artificials may be looked for before the rotation comes to an end. It is a little remarkable that on soil which proved to be ill suited for the action of artificial manures without dung in the last rotation, the results should be so good where the swedes were grown with artificials only, and the remarks made at page 13 may be recalled, viz., that the peculiarly dry summer of 1901 was favourable for swedish turnips grown without dung. The best crop on the four plots getting artificials only was grown on Plot 20. The character of this crop is obviously due to the effects of the muriate of potash. If it had not been for the results on Plots 21 and 22 the good crop on Plot 20 might have been attributed to the action of the residue of the dung applied in 1897 for potatoes. It will be remembered that for the first rotation Plot 21 received 18 tons of farmyard manure, and Plot 22, 24 tons per acre, and that the crops on the last were the best of the series. In 1900 Plot 22 would have been described as in very high condition, and it was expected that the swedes in 1901 would have benefited from the dung residue, but, as a matter of fact, so little has the residue affected the swede crop that Plot 21, which received 18 tons of farmyard manure in 1897, has produced rather less crop than Plot 19, which has received no farmyard manure for ten years or more; and Plot 22, in spite of the heavy dunging, is now not equal to land, which, while receiving but half the quantity of farmyard manure in 1897, had the assistance of 1 cwt. of muriate of potash for the swedes in 1901.

EXPERIMENTS ON OLD LAND HAY.

(TABLES X. to XIV.)

In the following table a list is given of the centres at which experiments on old land hay were carried out in season 1901. The table contains particulars of the area under the experiments, and also of the character of the soil at the different stations.

TABLE A.

Name of Station.	Occupier.	Date of Commencement of Experiment.	No. of Plots.	Total Area.	Remarks.
				acres.	
CUMBERLAND, SET I.					
Blencow	Mr. M. Walker ...	1895	16	¾	Clay loam on Old Red Sandstone.
Castle Carrock ...	Mr. J. W. Steele ...	,,	,,	,,	Light alluvium on Permian Sandstone.
Eskdale	Mr. T. Troughton ...	,,	,,	,,	Medium loam on Granite.
Glasson	Mr. G. Graham ...	,,	,,	,,	Peat.
CUMBERLAND, SET II.					
Brampton	Mr. J. P. Johnson ...	1895	16	¾	Deep sandy loam on Permian Sandstone.
Gosforth	Dr. Parker	,,	,,	,,	Light gravelly soil on Drift.
Kirkbampton ...	Mr. J. Holliday ...	,,	,,	,,	Loam on Boulder Clay overlying Lias.
Wigton	Mr. H. W. Pallister	,,	,,	,,	Poor clay.
DURHAM.					
Seaham	Messrs. The Seaham Harbour Stud Co.	1894	20	1	Medium soil on Boulder Clay overlying Magnesian Limestone.
Shield Ash	Mr. J. Robinson ...	1896	16	⅘	Medium soil on Sandstone.
NORTHUMBERLAND.					
Broomhaugh ...	Mr. C. Marshall ...	1893	20	½	Thin soil on Millstone Grit.

Effects of Season.—

The summer of 1901 was the worst for meadow hay which we have met with in the course of these experiments. A comparative statement is given below showing that the average crop on the unmanured land was worse by 3 cwt. per acre than in the bad season of 1896. It is to be noted, however, that the average crop on the *best* plot was as good as it was in 1896. This is due to the improvement that has since taken place in the soils from the use of manures. That there has been a considerable increase in fertility is evidenced by the fact that the best crop on the manured plots last season was just twice as good as the crop on the unmanured land.

Year.	Average produce per acre at 11 centres.	
	Unmanured Plot.	Best Plot.
	Cwt.	Cwt.
1896	18½	30¼
1897	19	35
1898	27	45¾
1899	22½	36
1900	22	42
1901	15½	30½
Average of 6 seasons at 11 centres.	20¾	36½

Although good as compared with some of the other plots, the best plot of 1901 produced less than three-fourths of the crop grown by the best plot in 1900, and but two-thirds of the crop grown by the best plot in 1898. Dry weather affects meadow hay much more than it does clover hay, partly because the latter contains the stronger plants, and partly because meadow hay is slower in beginning to grow, and so permits the ground to be scorched. Our stations furnish a fairly correct index of the condition of the crops in the North of England, and we may estimate meadow hay in 1901 to have yielded from two-thirds to three-fourths of an average crop.

Table B shows the effects produced by each of the past six seasons on the unmanured plot and on the best plot at four of our centres. These centres are situated in a line stretchi across the country from the east to the west coast. The dr weather has been most felt on the light soil of Castle Carroc The soils at Seaham and Eskdale are not very different an the results on the best plots of both stations were very simila but by comparing the figures for 1900 and 1901 it is eviden that the drought was more severely felt at the Cumberlan station than in Durham.

TABLE B.

Station.	1896.		1897.		1898.		1899.		1900.		1901.	
	Unmanured Plot.	Best Plot.	Unmanured Plot.	Best Plot.	Unmanured Plot.	Best Plot.	Unmanured Plot.	Best Plot.	Unmanured Plot.	Best Plot.	Unmanured Plot.	Best Plot.
	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cw
Seaham	23	41	10¼	21	38	54½	24	37	17½	39½	21½	4
Shield Ash ...	20¼	32½	22½	37	24¾	54¾	24¼	50¼	23¾	50½	17¾	34
Castle Carrock ...	15	31	22¼	46¼	30¾	46	22	39½	21	48	6¼	19
Eskdale	14¼	34¾	17¼	41½	16¼	33¼	27	48½	22¾	45½	12	45

RESULTS OF THE CUMBERLAND EXPERIMENTS
(SET I.).

The complete results of these experiments will be found Table X. The form of the table is somewhat different from that of previous years. It was the custom to average the produce of the four stations in each season, and to state the average crop for each year. These average crops up to 1900 will be found in the Ninth Annual Report. In Table X. o the present report the results obtained at each of the station have been kept separate. The produce of hay for 1901 i given, and also the average crop grown on each station in th last seven years.

The character of the experiments will be readily understoo by referring to the table in the appendix. Their chief objec is to show which constituent of a mixed manure produces th greatest effect; then to compare the action of slag and super phosphate; of sulphate of ammonia and nitrate of soda; and of farmyard with artificial manures.

Abstract of Results.—

A summary of the results obtained on the plots at Castle Carrock, Eskdale and Glasson* is given in Table C. The figures show the average increase produced by various combinations of manures over Plot 1, the unmanured plot.

TABLE C.

Plots.	Treatment.	Average Cost of Manure per Acre per annum.		Average Increase per Acre in		
				Seven Years.		Five Years.
				Castle Carrock.	Eskdale.	Glasson.
		s.	d.	Cwt.	Cwt.	Cwt.
	Complete v. Partial Manuring—					
9	Manure supplying Nitrogen, Phosphates, and Potash	21	9	10¾	17¼	11
8	Manure supplying Phosphates and Potash only	13	5	6	14¾	8¼
7	Manure supplying Nitrogen and Potash only	14	7	8	11¾	5¾
6	Manure supplying Nitrogen and Phosphates only	15	8	3¼	10	10¾
	Superphosphate v. Slag—					
9	Complete Manure supplying Phosphates in Super.	21	9	10¾	17¼	11
10	Complete Manure supplying Phosphates in Slag	18	11	9¼	16¾	11¾
11	Complete Manure supplying Phosphates half in Super and half in Slag	20	5	11¼	15¾	12¾
	Nitrate of Soda v. Sulphate of Ammonia—					
10	Complete Manure supplying Nitrogen in Nitrate	18	11	9¼	16¾	11¾
12	Complete Manure supplying Nitrogen in Sulphate...	18	6	7¾	10¼	12
	Best Artificial Mixture v. Farmyard Manure—					
11	Artificial Mixture	20	5	11¼	15¾	12¾
16	Farmyard Manure	28	7	8¼	18¾	10

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* At the fourth station, Blencow, the soil is not quite uniform and some of the results are unreliable.

With the average results of a series of years now before us in Table C, we are able to answer several questions of importance to Cumberland farmers.

Which is the most important Constituent of the Artficial Mixture? (Plots 1, 6, 7, 8, 9).—

In marked contrast to the results at Cockle Park and Seaham on the east coast, we find that on the light soils at Castle Carrock and Eskdale a potash manure has been the most effective component of the general manure used upon Plot 9. Even when employed by itself, in the form of 2½ cwt. kainit, the dressing of potash has been markedly beneficial on the former station. On peat at Glasson, phosphates were more wanted than potash, but at this station kainit was the best of the single manures employed on Plots 2 to 5; the presence of a second plant food was necessary to make an application of phosphates of marked value. At two of the three stations a manure containing phosphates and potash only, has been slightly more profitable than a complete manure, but except where the soil is specially favourable for the growth of red clover and other tall leguminous plants, a complete artificial mixture is likely to prove the most profitable over a series of years on meadow land.

Superphosphate and Slag. (Plots 9, 10, and 11).—

So far as the yield is concerned these phosphatic manures have produced closely comparable results, and as slag is considerably cheaper, it would appear that even on light soils it may be profitably employed for meadow hay. On the average there has been little advantage in using a combination of the two manures on these stations, but from our experience of mixed manures at other centres we think that a farmer who is in the habit of using phosphatic manures for his meadow land should occasionally vary the source of phosphates, that is, if the soil is light; on heavy soil the first dressing should always consist of a liberal application of slag, and this should be followed up after several years either by superphosphate, or a second, lighter dressing of the insoluble phosphate.

Nitrate of Soda v. Sulphate of Ammonia. (Plots 11 and 12).—

On two out of the three stations, nitrate has proved to be distinctly the better manure for meadow hay. The effect on the quality of the hay has not been determined, but on the majority of soils there is no reason why the quality of the herbage grown with these manures should be different. When heavy dressings are employed, the quality often is different, but any farmer who uses either, or both, intelligently is not likely to find much difference in the quality of the produce.

At Eskdale, sulphate of ammonia was very inferior to nitrate. Samples of this soil have been taken for the purpose of analysis, and the subject will be returned to in a subsequent report.

Farmyard Manure v. Artificials. (Plots 11 and 16).—

The artificial mixture used on Plot 11, though not the best at each station, was on the average slightly superior to the very similar manures used on Plots 9 and 10. This mixture cost 20s. 5d. per acre. How does it compare with farmyard manure? Plot 16 has received four applications of dung in seven years, in all 40 tons; at 5s. per ton, the average cost would be 28s. 7d. per acre per annum; the average result on two stations is distinctly in favour of the light manure, on the third the dung has produced 3 cwt. more hay; 7s. 6d. worth of crop, at a cost of 8s. 2d. Apart from the question of quality, therefore, this means that if 5s. per ton can be made out of farmyard manure by using it on tillage land, the meadows, which on most farms are much less likely to need dung, may be economically dressed with artificials. From the other point of view, these experiments show us that if a farmer can spare dung for his (light soil) meadows a dressing averaging about 6 tons per acre per annum will produce as good results as 15s. to 20s. worth of artificials. The quality, too, will probably be better, for it is easier for a farmer who is not skilled in the use of artificial manures to obtain good quality from the use of the home manure than from purchased fertilisers. At Eskdale, where dung did very well, an addition of 5s. 6d. worth of artificials produced only 1 cwt. extra crop, but at Castle Carrock the artificial mixture was very profitable, producing no less than 6¼ cwt. hay. For further details respecting the effects of dung and artificials when used together see Table X.

RESULTS OF THE CUMBERLAND EXPERIMENTS (SET II.).

The complete results of these experiments are given in Table XI. The figures in this table have been treated as those of the Cumberland stations, Set I. The average figures represent the average returns on each station for the whole period, *not*, as formerly, the averages of four stations in each year.

The objects of these experiments are: (1) To ascertain in what proportions the three ingredients of a complete manure should be mixed; (2) to compare superphosphate, slag, dissolved bones, and bone meal, and also fish meal and nitrate of soda; (3) to compare the effects of complex manures with simple manures; (4) to test the effects of employing lime with artificial manures.

Abstract of the Results.—

Table D shows the average increase produced at Gosforth in six years, and at the other stations in seven years as the result of the special treatment received by each plot. The figures in the table answer the question, In what proportion should the constituents of a general artificial manure be blended?

TABLE D.

Plot.	Manuring per Acre. Manures applied in four years out of seven, viz., 1895, 1897, 1898, and 1900.	Average per acre per annum.				
		Cost of Manure.	Increase.			
			Brampton.	Kirk-bampton.	Gosforth.*	Wigton.
		s. d.	Cwt.	Cwt.	Cwt.	Cwt.
2	Standard Plot { 1 cwt. Nitrate of Soda 3⅝ „ Superphosphate 3⅝ „ Kainit } ...	14 11	6¼	11	7¼	4¼
3	50 per cent. **less Super.** than Standard ...	12 2	4¼	11¾	3½	3¼
4	50 „ **more** do. do. ...	17 8	5¾	8½	8	8¾
5	50 „ **less Kalnit** than Standard ...	12 8	4¾	5¾	5	8¼
6	50 „ **more** do. do. ...	17 3	7½	9	5¾	9¾
7	50 „ **less Nitrate** than Standard ...	12 6	9¼	6¾	4¾	4¼
8	50 „ **more** do. do. ...	17 6	9¾	10	6¾	8¼

Some of the results are contradictory, and except at Wigton, where one or two of the plots are unequal in character, the inconsistencies cannot readily be accounted for. At Brampton the experimental field appears to be very uniform, and in most seasons the figures have been consistent; but last summer Plots 7 and 8 both produced much better crops than Plot 2, a result which in the case of Plot 7 would seem to be partly accidental and due to the soil being more retentive than that of Plot 2. At the same time the history of this plot indicates that it has undergone some change as the result of its treatment. In the four seasons, 1895-98, Plots 2 and 7 averaged respectively 28½ and 29½ cwt. of hay, but latterly Plot 7 has been much the more productive. At Kirkbampton, Plot 8 is probably slightly inferior to Plot 2, but here again there is evidence that the treatment is accentuating the natural inequality of the soil, for at the end of the first five years Plot 8 was better than Plot 2, now it has fallen behind.

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* Average of six years 1895-1900 only.

The figures in Table D are certainly not so inconsistent as at first sight they appear to be. It must be remembered that in using artificials, it is just as wrong to apply too much as to apply too little, thus when we find that the increase or the decrease of superphosphate at Brampton, and the increase or decrease of kainit at Gosforth injuriously affect the crop, the probability is that the standard quantity is the best, *not* that the result is an accident.

For Kirkbampton soil the proportions of the mixture used for Plot 2 would seem to be most suitable, on Brampton a manure containing less nitrogen and more potash, and on Gosforth and Wigton a more liberal use of phosphates, would probably yield greater profits than the mixture applied to the standard plot.

Some further results of the experiments at these Cumberland stations are summarised in Table E. As in the other tables the figures show the average annual increase per acre in the weight of the hay crop resulting from the use of the manures named.

Comparison of some Common Manures.—

Plots 7, 9, 11 and 12 have all received the same quantity of phosphates and nitrogen, the first two in superphosphate, slag and nitrate of soda, the others in dissolved bones and bone meal. The bone manures have been distinctly the more effective on the very sandy soil of Gosforth, but at the other stations they have not done better than the cheaper compound containing slag and nitrate of soda. From the results obtained with fish meal (compare Plots 10 and 13) it may be inferred that the superiority of the bone manures at Gosforth was due to the manner in which nitrogen was supplied; as sources of phosphate there seems, in point of efficiency, little to choose between the four manures, the cheapest, viz., slag, was as good as any. The similarity of the effects produced by the manures used on Plots 7, 9, 11 and 12 is shown by the aggregate annual averages which for four stations amount to 25,

TABLE E.

Plots.	Manuring per acre, Manures applied in four years out of seven, viz. in 1895, 1897, 1898, and 1900.	Average per acre per annum.					
		Cost of Manure.		Increase.			
				Brampton.	Kirk-bampton.	Gosforth.*	Wigton.
		s.	d.	Cwt.	Cwt.	Cwt.	Cwt
	Comparison of Superphosphate, Slag, etc.						
7	Mixed Manure containing Super.	12	6	9¼	6¾	4¾	4¼
9	Similar Manure containing Slag	10	7	8½	7¾	5	9½
11	Do. Dissolved Bones ...	13	3	8½	6	7½	7¼
12	Do. Bone Meal	11	2	6¾	7½	7½	9¼
	Comparison of Nitrate and Fish Meal—						
10	Mixed Manure containing Nitrate of Soda ...	12	4	11¼	7¾	5¾	9¾
13	Do. Fish Meal	10	11	9½	6¾	7	6¼
	Benefit from use of a Complex Manure—						
14	Manure containing ⅕th dressings of Plots 7, 9, 11, 12, 13	11	8	11½	12	10¼	5½
—	Average increase in crop grown on Plots 7, 9. 11, 12, 13	11	8	8½	8½	5¼	7
	Heavy v. Light Dressing—						
14	6¾ cwt. Mixed Manure	11	8	11½	12	10¼	5½
15	3⅜ do.	5	10	9¾	4½	1½	5¼
	Effect of Lime—						
15	3⅜ cwt Mixed Manure	5	10	9¾	4½	1½	5¼
16	do. + 5 cwt. Ground Lime ...	8	5	4½	5¼	¼	1

* Average of six years 1895-1900 only.

30¾, 29¼ and 31 cwt. respectively. Owing mainly to its position at Wigton, Plot 7 is a little inferior, the others are practically equal, and in point of profit, though Plot 9 stands first, Plot 12 is a very close second.

Nitrate of Soda v. Fish Meal.—

Having seen that basic slag is, on the whole, the best source of phosphate, we next ask, "Should we use along with slag a quick-acting manure like nitrate of soda or a slow manure like fish meal?" On the sandy soil of Gosforth the fish meal has produced the heavier crop, but elsewhere nitrate of soda has been distinctly the more effective.

The Value of a Complex Manure for Meadow Hay.—

At p. 72 of last year's Report it was remarked that, except on those soils markedly improved by basic slag, complex manures should be employed for meadow hay. The desirability of employing a complex mixture is clearly indicated in Table E. On three of the four stations there has been a substantial profit from the complex manure used on Plot 14. The average increase on Plots 7, 9, 11, 12 and 13 amounted to 7¼ cwt. of hay, grown at a cost of 11s. 8d.; but the average increase on Plot 14, which received one-fifth of the collective dressings of these five plots amounted to 9¾ cwt.; we thus have a gain of about 7s. worth of hay per acre per annum as the result of mixing the dressings. We find further that the complex mixture is the more certain in its action. At three out of the four stations Plot 14 has grown the best crop, and on two of them very much the best crop on the field. On the fourth station, where the soil is rather irregular, it may be inferred from a comparison of Plots 14 and 15 that the former is somewhat below the general average in quality.

Heavy v. Light Dressings.—

The smaller dressing used on Plot 15 has done remarkably well at Brampton, but over the four stations the larger amount has been the more profitable, and an expenditure of 6s. per acre per annum on the manuring of meadow hay is certainly too little. It is probable that if the 27 cwt. of manure applied to Plot 14 had been uniformly distributed the results would have been better than they are, so that 3½ cwt. per acre per annum of the mixture used for Plot 14, costing roughly 10s., would have grown as good a crop as the 27 cwt. applied in four dressings at an annual cost of 11s. 8d.

The effect of Ground Lime.—

Plots 15 and 16 were treated alike, but in the latter case, in addition to the manures 5 cwt. per acre of lime was applied. The result has been a very marked decrease on the sandy soils of both Brampton and Gosforth, and a trifling increase on the stiffer soil at Kirkbampton. From the appearance of the herbage it is quite plain that lime is not promoting the growth of meadow hay on these Cumberland stations.

Manurial Residues.—

In the case of meadow hay the effects of manures may show themselves in the years following their application in three distinct ways: (1) Because of the action of that portion of the manure which has lain over unused in the soil; this may often be the case after a dressing of bone meal, slag, etc. (2) The larger crop grown under the influence of manure leaves a greater vegetable residue in the soil, and the decomposition of this residue will assist future crops; the effect is of regular occurrence in meadows, but the farmer is most familiar with an example seen on arable land, when the use of some such manure as slag or kainit stimulates the clover crop and so indirectly, supplies food for the following cereal. (3) A manure may encourage the growth of a plant in one season, and the invigorated plant may for several years continue to produce larger crops; when, after an application of basic slag, a pasture becomes covered with white clover we have an example of this third kind of residue; for although the slag remains in the soil and continues to feed the clover, the main result is brought about by the way in which the strengthened clover plant helps itself. Strictly speaking, the first effect only can be said to be due to manure residue, but to farmers the term "manurial residue" implies all after effects direct and indirect produced by manures; nor is there any reason to object to this use of the term. Apart from indirect action the residues of manures would be of little importance to the practical agriculturist. It is because of their indirect action that we have fertility increasing (cumulative fertility) as the result of the judicious use of light manures. When bones and some other manures are employed we may have a slight direct accumulation of fertility, which will last for a year or two, but practically this kind of cumulative fertility is of small account. The accumulation that is of value begins when the light manure leaves the soil and enters the plant.

But the manure may not always leave a valuable residue even when it does enter the plant. Meadow herbage may suffer as a result of a vigorous growth brought about by manures in the previous season. On dry soils especially, plants may become feeble after producing a "forced" crop under the influence of a nitrogenous manure. It was pointed out in last year's Report that on the light and dry soil at Gosforth the residue was of a negative character, but that on deeper land at Brampton and Kirkbampton the after effect of the manures was to produce a moderate increase of crop.

Last season, unfortunately, the crops at Gosforth were not weighed, and so no fresh figures are available from this centre, but in Table F the results at the other stations will be found.

The manures have been used altogether in four seasons, and have been omitted in three. The average increase on certain plots in the four manured years and also in the three unmanured years is given below.

TABLE F.

Plot.	Manuring.	Average Increase compared with the Unmanured Plot at			
		Brampton.		Kirkbampton.	
		Manure Applied.	Manure Withheld.	Manure Applied.	Manure Withheld.
		Cwt.	Cwt.	Cwt.	Cwt.
7	½ cwt. Nit. Soda... ... 3½ „ Super. ... ... 3½ „ Kainit	11¾	5¾	10¾	¾
9	½ cwt. Nit. Soda... ... 3 „ Slag ... ... 3½ „ Kainit	9½	7	10¼	4
11	3 cwt. Dis. Bones ... 3½ „ Kainit	11	5	8¼	2½
12	2¼ cwt. Bone Meal ... 3½ „ Kainit	8	5	9¾	4
13	1 cwt. Fish Meal ... 2½ „ Slag ... ... 3½ „ Kainit	11	7¼	10¾	2
14	⅕ of Collective Dressings of above Plots	14¼	7¾	17	5
	Average of six Plots ..	11	6¼	11	3

At both stations the effects of the manures in the year after application were very considerable; on the average of six plots we find the "residue increase" at Brampton more than one-half, and at Kirkbampton more than one-fourth of the "original increase."

The effects of the residues of bone meal and of slag were proportionately greater than those of dissolved bones and of superphosphate, but neither "slow-acting" manure left so useful a residue as the mixture employed on Plot 14, and it is plain that the best way to secure a large residue on land sufficiently supplied with moisture is to grow a strong, healthy crop.

On the ordinary soil devoted to growing "old land hay" in the North of England, it is the vegetable and not the mineral residue that is likely to have most value, and it is quite possible that the proper use of such a manure as nitrate of soda may furnish a residue worth more than that left by bones. Nitrate of soda may, of course, injure both the hay and the residue if it enables the taller grasses to choke out the "bottom" plants, but if intelligently used there is no reason why it should do this. So long as the farmer maintains the mixed character of the meadow herbage there is no reason to fear that heavy hay crops will prove exhausting.

SHIELD ASH, WEARDALE.

The results at this station are shown in Table XII. In last year's Report the tendency of the plots at Shield Ash to accumulate fertility was pointed out. It was shown that the increase grew larger each year. The very dry summer of 1901 checked this upward tendency, but from the detailed figures which have been printed in the table, it will be seen that even in this extremely unfavourable season the crops grown on a number of the plots, for example, on Plots 3, 4, 10 and 11, were distinctly better than they were in the more favourable seasons of 1896 and 1897. At this station the best results have been got from the slow acting manures used on Plots 9 and 10. The combination of slag, fish meal and kainit on the former has left an average profit of 30s. 9d. per acre, and the combination of bone meal and kainit used on the latter has left a profit of 32s. 5d. It should be pointed out, however, that the soil on Plots 9, 10, 11 and 12 appears to be rather better than the soil on the other sections.

BROOMHAUGH.

Table XIII. gives the results of the experiment at Broomhaugh. The dry season proved disastrous to the hay crop on the poor, thin, Millstone Grit soil of this station, and the best crop harvested was under 15 cwt. per acre. This crop was grown with the aid of farmyard manure. The best crop grown with artificials only was 11½ cwt.

The results at Broomhaugh emphasise the necessity of using potash manures on certain soils. With phosphates only the average profit has been 5d. per acre. With potash only, there has been an average loss of 6s. 11d., but where the two have been combined the loss has been turned into a profit of 13s. 11d. per acre. Another noticeable point in connection with this station is the very much better result yielded by nitrate of soda, than by sulphate of ammonia. The adjacent Plots 8 and 9 are treated in every way alike, except that the former receives 1 cwt. nitrate and the latter three-quarters cwt. sulphate, the manure used on Plot 8 has left a profit of 15s. 11d., and the manure used on Plot 9 has resulted in an average loss of 5d. per acre.

SEAHAM HARBOUR.

The results of the experiments at Carr House Farm, Seaham Harbour, are given in Table XIV. This is an interesting experiment, but the figures obtained from it are very disappointing. The land is uneven in character, and although the manures have produced marked results which are plainly visible on the crop, these results when set out in figures are contradictory and of little value. The experiment is continued with the object of showing how the manures influence the botanical composition of the herbage, and some years hence a careful botanical survey will be made. The most remarkable plot at this station is No. 4. Here, as the result of using kainit, the soil has undergone very distinct deterioration.* The grasses are now dying away in patches, and the surface in parts has the look of bog land, dried and scorched by a summer sun. Last season it will be observed that the crop on Plot 4 was 5½ cwt. less than on the unmanured land, and its poverty was so marked that the outline of the plot could be seen from some distance. The heavy dressings of superphosphate used on Plot 3 have done even worse financially than the kainit, but the herbage, although far from good, is moderately healthy. Of the single manures, nitrate of soda has done much the best. It has even shown a profit, and the fact that the eighth crop grown with no other manure than 1 cwt. nitrate of soda amounted to nearly 30 cwt. per acre in such a season as we had last summer shows that the exhausting effects of this manure cannot be of a very serious character at Seaham.

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* Probably in this particular case owing to the accumulation of soluble salts in the surface soil.

Summary.—

(1) Experiments on old land or meadow hay have been carried on at eleven centres for from six to eight years.

(2) The crop has in all cases responded readily to liberal treatment and last season the average crop on the best plots was double that grown by the unmanured land.

(3) The most important component of a mixed artificial manure varies in different districts, and without field trials it is impossible to say whether meadow hay will respond best to a nitrogenous, a phosphatic or a potassic manure. As meadow herbage is a mixed crop its requirements are much less definite than those of the pure crops grown on arable land.

(4) Slag has proved the cheapest single source of phosphates and nitrate of soda the cheapest source of nitrogen at most of the centres.

(5) Except in the case of those poor clay soils that are naturally adapted for slag, land for meadow hay should always be dressed with complex manures, that is, manures in which the constituents, nitrogen, phosphates and potash are each supplied from several different sources. The

following complex manure is similar to one which has given the best results on the Cumberland hay plots (see Table XI., Plot 14):—

1 cwt.	Slag ...	in November	To be applied to from one to two acres, at the seasons indicated. The proportions of Slag, Muriate and Nitrate, may be varied until the most suitable is found.
½ „	Bone Meal ...		
1 „	Superphosphate	in February or March	
⅓ „	Dissolved Bones		
¼ „	Fish Meal ...		
½ „	Muriate of Potash		
1 „	Kainit ...	in end of April	
¼ „	Nitrate of Soda		

Sulphate of ammonia, phosphatic guanos, precipitated bone phosphate and sulphate of potash, may be substituted for the corresponding manures in the foregoing mixture when they can be purchased on more favourable terms.

(6) Ground lime has not benefited any of the four Cumberland stations on which it has been used. (At Cockle Park on "slag" land this substance has been beneficial when used along with heavy dressings of superphosphate.)

(7) On a dry sandy soil artificial manures have left little or no residue, but on light and medium loam soils a very considerable improvement was produced by artificial manures in the year following their application. In manuring his fallow land the farmer has to consider the requirements of a whole rotation of crops, but in manuring meadows he should concentrate his attention on the immediate object—the production of a vigorous, well-mixed crop of hay. For most northern meadows slow-acting manures, as such, have no special value and if the farmer takes care that his hay crop is of the right kind, in quality and quantity, the residue may be left to take care of itself.

REPORT OF THE LECTURER IN AGRICULTURAL CHEMISTRY, FOR 1901.

(S. H. Collins, F.I.C., F.C.S.)

This report contains the result of the chemical work done during the Season 1901 so far as it has been completed, together with some of the results of former seasons which have been held back for completion or verification.

Methods of Analysis.

Some notes on the methods of analysis were printed in the last Report (1900, p. 179). Since then the colorimetric method of estimating sugar has been more fully worked out and exact details published in the *Journal of the Society of Chemical Industry*, 1901, p. 536. An abstract has also been published in the *Journal of the Chemical Society*, 1901, Aii, 583. This method has been used for nearly all the determinations of sugar reported on.

In soil analysis "soluble in hydrochloric acid" means the portion extracted in 48 hours at 100° Cent. by strong acid. "Soluble in citric acid" refers to the method of soil extraction originally devised by Dr. Bernard Dyer, details of which are published in the *Journal of the Chemical Society*, 1894, p. 115, and *Philosophical Transactions* of the Royal Society of London, B, vol. 194, 1901, pp. 235-290. The soil extract so obtained has been employed not only for the estimation of potash and phosphoric acid, but also for lime, iron and silica. The figures for lime appear to have some value (see p. 111).

Although the estimation of "dry matter" in swedes seems a matter too elementary to need any remarks, yet in dealing with the enormous amount of material needed for these investigations, many alterations have been found necessary.

Something like 50 gallons of water have had to be evaporated from the swedes and potatoes, an amount quite beyond any ordinary apparatus. For the class of work required in the estimation of dry matter in swedes and potatoes low temperatures are necessary; from 50° to 60° Cent. having been employed. Special jacketted hot-air ovens were accordingly built, these being heated by gas regulated by thermostats to maintain the above temperature.

Methods of Sampling.—

Individual swedes for the sugar breeding experiments have had a single core taken through the centre to represent the whole swede. Swedes in bulk have had 100 roots selected to be as average as possible and cored and dried in two lots of 50. As a rule the two lots gave similar figures, where they did not a note has been appended, or, if the divergence was great, the sample rejected altogether. The work of the past season has only tended to confirm the opinion expressed before; that 25 swedes is the very lowest number that can possibly be representative of a whole crop, that cores right through the centre afford the cleanest and most satisfactory way of sampling the actual roots selected. By employing 50 roots in duplicate the results have on the whole been very uniform and have given great confidence in this method of sampling. In many cases averages of larger numbers still, have formed the basis on which the conclusions have been made. The number of swedes which have been used for Table XV. is 8,600, and at other stations than Cockle Park 3,500, which together with the work of the sugar breeding experiment, yellow turnips and preliminary tests, makes about 15,000 turnips as the total number used for these investigations from 1900 to the present time. Such a large number involves much labour in sampling, nearly all of which has been performed by Mr. F. Wakerley, B.Sc.. who has, as the result of much experience and trouble, evolved an excellent sampling iron for the purpose.

In the case of potatoes, most of the estimations of dry matter have been done on slices. Borings have also been tried, and I am instituting an experiment to find out which way forms the more accurate method of sampling; the results will be kept over till next year's Report as they are not yet finished.

EXPERIMENTAL WORK.

A large number of swedes have been sampled both this season and last in order to find out what is the variation in composition due to variety, soil, manure, season and storing. Twenty varieties have been tested at Cockle Park over two seasons, and in the first season both before and after storing. A few varieties have been grown on different farms with different manures.

What is the "best" Swede?—

A good variety of swede must not merely be a good cropper but must have as little useless water and as much valuable food material as possible.

Although it is improbable that any variety of swede would be the best under all conditions of soil and season, yet it may be reasonable to expect to find a few varieties which will, on a particular farm, give the best results whatever the season may be.

Probably certain varieties will prove best not merely on a farm but over a fair sized district. The subject of the quantity of produce is referred to by Prof. Middleton on p. 10.* The following remarks apply to quality only except where otherwise stated.

Table XV. gives the composition of swedes grown at Cockle Park in both 1900 and 1901, the swedes of 1900 having been stored and analysed after storage as well as before.

It is necessary to divide up the various issues included in this table before they can be comprehensible. It will be seen at once that the season 1901 has had a prejudicial effect on quality if not on quantity (compare p. 13); but as we require to know the relative merits of the different varieties under diverse circumstances, the results of the two seasons 1900 and 1901 will afford most valuable information.

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* See also Cockle Park Report for 1901.

The farmer cannot control the season; what he requires to know is, which variety will produce the best result, whatever the season may turn out to be. In spite of the extreme diversity of the nature of the two last seasons, the order of excellence of the different varieties tested at Cockle Park has proved nearly the same in each season. We are therefore justified in assuming that the results would prove the same in any season (see p. 9).

In other words whilst season does affect composition, yet the variation in composition of swedes due to difference of season is approximately the same whatever the variety may be.

Dry Matter.—

If the varieties of swedes in Table XV. are placed in the order of their percentage of dry matter, beginning with the best and ending with the worst, we have, in the 11 varieties

ORDER OF MERIT OF VARIETIES OF SWEDES ACCORDING TO PERCENTAGE OF TOTAL DRY MATTER.

	1900.	1901.
Best ...	Fells Bronze Top (12·38)	Webb's Arctic (10·87)
	Carter's Elephant	Carter's Elephant
	Webb's Arctic	Stirling Castle
	Carter's Kangaroo	Crimson King
	Crimson King	Fell's Bronze Top
	Stirling Castle	Carter's Kangaroo
	Extra Improved	Monarch
	Monarch	Extra Improved
	Best of All	XL. All
	Model	Best of All
Worst ...	XL. All (10·47)	Model (9·46)

tested throughout the two seasons, a table shewing that the order of merit of varieties is fairly constant in different seasons.

Whilst the amount of food material has fallen off in the past season, the order of merit is little changed, the six best varieties and the five worst being the same in each season. So far as the one farm of Cockle Park is concerned Carter's Elephant and Webb's Arctic seem the varieties which contain the greatest amount of total food material.

Webb's Arctic maintains a high level throughout, Carter's Elephant keeps badly, but maintains a fairly high position throughout.

Kangaroo, Stirling Castle and Crimson King maintain good medium positions in the list.

The other varieties have little to recommend them so far as composition is concerned.

Keeping Qualities.—

In addition to giving good crops and containing a high proportion of total food material in all seasons, a good variety must keep well on storing. During storage part of the food

ORDER OF MERIT AFTER STORAGE, CROP OF 1900.

Best ...	Fell's Bronze Top
	Extra Improved
	Webb's Arctic
	Carter's Kangaroo
	Stirling Castle
	Carter's Elephant
	Crimson King
	Best of All
	Monarch
	Model
Worst ...	XL. All

material is lost, but, as some of the water is lost also, the swede may contain a greater proportion of food than before. How much water is lost during storage has not been determined; it will depend on the method of storing rather than on the variety, and therefore forms a separate enquiry which will have to be deferred. In these experiments all the swedes were stored in the same way, being placed in sacks on a wooden floor and covered over lightly with straw.

If the varieties are now arranged in the order of merit after storage (see p. 98) we can compare the results with the similar table above.

Sugar.—

The most valuable food material in the swede is sugar; before coming to a definite conclusion as to the best swede for feeding purposes, the amount of sugar present must not be neglected.

Putting them into order as before we have the following table.

ORDER OF MERIT OF VARIETIES OF SWEDES ACCORDING TO THE PERCENTAGE OF SUGAR.

	1900.	1901.
Best	Fell's Bronze Top	Webb's Arctic
	Stirling Castle	Fell's Bronze Top
	Webb's Arctic	XL. All
	XL. All	Crimson King
	Extra Improved	Stirling Castle
	Crimson King	Best of All
	Carter's Elephant	Carter's Elephant
	Model	Model
	Kangaroo	Kangaroo
	Best of All	Extra Improved
Worst	Monarch	Monarch

Fell's Bronze Top and Webb's Arctic again occupy high positions, Stirling Castle somewhat rises in importance and Elephant and Kangaroo go down. X.L. All is the variety which shews greatest change; judged by the standard of sugar it should be considered among the best. A high proportion of sugar compared to the other food materials has perhaps its danger, for if we observe the keeping qualities we see that this variety has fallen again to the bottom of the *list.*

ORDER OF MERIT AS REGARDS SUGAR AFTER STORAGE,
CROP OF 1900.

Best	Fell's Bronze Top
	Extra Improved
	Kangaroo
	Webb's Arctic
	Elephant
	Stirling Castle
	Best of All
	Crimson King
	Monarch
	Model
Worst	X L All

Fell's Bronze Top and Webb's Arctic are certainly the most satisfactory all round at Cockle Park. Kangaroo, Elephant, Stirling Castle and Crimson King are good uniform medium varieties; Extra Improved and X.L. All are somewhat erratic, and Best of All, Monarch and Model are always among the poorest varieties. Best of All has, however, done better at some of our other Experiment stations.

Alteration in Composition during Storage.—

Besides the question of the alteration in the amount of dry matter and sugar in the swede due to storing, there is the question of the alteration in the amount of albuminoids and other bodies in the swede. Owing to lack of time only one variety has been tested, namely the "Monarch" which was used in sheep feeding experiments.* In Table XVI. these results are set out shewing clearly that the chief change is due to the pectins having been converted into sugar and the amides and albuminoids having largely disappeared. This loss of nitrogen appears to be very serious if it occurs generally. Further experiments will be needed before coming to conclusions on the matter.

It will be noticed that these swedes have less nitrogen and ash than the swedes of the same variety grown at Cockle Park in 1899 (see Annual Report 1900, p. 211). The lower amount of nitrogen in the 1900 crop occurs mostly in the comparatively useless amide form, the amount of albuminoids being only slightly less; the amount of sugar is greater in the 1900 crop than in the 1899 crop. It is only the 1901 crop that is deficient in sugar at Cockle Park.

Results at New Raby Farm.—

Four of the above varieties were tested at Raby this season under uniform conditions† (see Table XVII. p. 144). Unfortunately only those varieties which have proved of low merit at Cockle Park were used at this farm. They all did much better here, but the difference between one variety and another is hardly enough to justify any comparison. In fact the difference in composition is more pronounced between the same variety at the two farms than between different varieties at the same farm. Whether this result would have happened if varieties which differed at Cockle Park had been tried cannot be known till the experiment has been repeated on more systematic lines. If varieties which differ little at Cockle Park also differ little at Raby Farm it is at least probable that varieties which differ much at the one farm will differ much at the other. There is therefore no reason for supposing that the order of merit of the varieties of swedes is different at one farm to what it is at another, but a carefully planned experiment must be carried out before this point can be proved.

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* At Cockle Park in the Spring of 1901.

† They were grown with farmyard manure and without artificials.

Is there a "best" Swede?

The above experiments shew that for one farm there are certain varieties which have a much superior quality to others. It will be noticed (see Table XV.) that some of the newer varieties which were tested this season for the first time have proved of superior quality to the others, and that some of the most popular varieties are among the poorest in quality. Probably these two facts are due to the same cause, that new and unknown varieties are grown for seed with great care, whilst those varieties which have already become well known are grown for seed without due precautions being taken.

In attempting to answer the question "what is the best swede?" it is necessary, therefore, perhaps to consider the question of the age of the variety as well as its name. The place where it was grown must also have an effect. Transplanting varieties of sugar cane to districts different in climate from that of their origin has been found to temporarily depreciate their value though after a few years they become acclimatised. Analogy would lead us to suppose that the same decrease in quality would result in the case of swedes. Our own home-grown variety "Monarch Disease Resisting" (see Table XV.) stands second in the list as regards dry matter and top as regards sugar. Yet the parent stock of this variety is the "Monarch" which is one of the poorer varieties. These considerations lead to the conclusion that the name of a variety is not in itself sufficient to determine the value of seed. The district where the seed was grown and the care taken in growing it are alike of great importance.

Effect of Soil and District

on the composition of the swedes may be seen by comparing the composition of swedes grown at Cockle Park with that of those grown at other experiment stations. Some of the varieties named above have been grown with various manures on farms in Durham. For the present enquiry the average composition of all the plots at each station will be employed.

"BEST OF ALL" SWEDE.

Grown at	Soil.	Dry matter (per cent).	Sugar (per cent).
Cockle Park	Loam	9·63	4·05
Cleatlam	Gravel loam ..	10·85	5·05
Neasham Grange ...	Alluvium ...	10·55	4·66
Newlands Haugh ...	Loam	10·07	4·73
New Raby	Gravel	11·23	5·45
Birtley	Strong loam ...	11·44	5·53

The other varieties tested in this way give, on the whole, the same result. At Cockle Park a dry season has given a wet swede, the crop was, however, sown rather late; the short period of growth accounting for the poor quality.

Another season's trials will be necessary before we can draw very satisfactory conclusions on this subject.

KENT & BRYDON'S XL ALL SWEDE.

Grown at	Soil.	Dry matter (per cent.)	Sugar (per cent.)
Cockle Park ...	Loam	9·92	4·40
New Raby ...	Gravel	11 02	4·75

DRUMMOND'S EXTRA IMPROVED SWEDE.

Grown at	Soil.	Dry matter (per cent.)	Sugar (per cent.)
Cockle Park ..	Loam	10·13	3·60
New Raby ...	Gravel	10·66	4·87

KENT & BRYDON'S DARLINGTON SWEDE.

Grown at	Soil.	Dry matter (per cent.)	Sugar (per cent.)
Cockle Park ...	Loam	10·18	4·05
New Raby ...	Gravel	11·02	4·75

Effect of Manures.

The effect of manures can be traced by comparing the proportion of dry matter and sugar in the swedes grown by different systems of manuring (see page 127). The results of five different manures at seven different stations are compared in the accompanying table. The average percentage of dry matter is highest on the unmanured and lowest on the heaviest manured plot. This is also true of four out of seven individual farms.

VARIATION IN COMPOSITION DUE TO MANURES.

Station.	Dry Matter (per cent.).				
	Manures.				No Manure.
	Complete Artificial.	No Nitrogen.	No Phosphates.	No Potash.	
Cleatlam	10·17	10·48	11·18	10·83	11·61
Neasham Grange ...	9·95	10·85	10·55	10·48	10·93
Medomsley E. ...	12·04	12·60	12·36	12·35	12·60
do. W. ...	10·88	12·05	11·11	12·08	12·24
Newlands Haugh ...	9·94	9·57	10·45	10·39	9·69
Sherburn	12·51	11·19	10·15	10·44	12·49
Birtley	11·34	11·44	11·63	11·29	11·51
Average ...	10·98	11·18	11·06	11·12	11·58

The variation in the percentage of sugar is smaller and less constant but follows the same general law that the crop on unmanured land is richer, and that consequently the value of the improvement due to manuring is slightly exaggerated in the ordinary manurial trials.

VARIATION IN COMPOSITION DUE TO MANURES.

Station.	Sugar (per cent.).				
	Manures.				No Manures.
	Complete Artificial.	No Nitrogen.	No Phosphates.	No Potash.	
Cleatlam	4·95	5·10	4·93	4·92	5·33
Neasham Grange ...	4·32	5·06	4·58	4·57	4·75
Medomsley, East ...	5·93	6·30	5·96	6·15	6·24
Do., West ...	5·25	6·27	5·36	5·94	6·21
Newlands Haugh ...	4·66	4·61	4·95	4·90	4·52
Sherburn	6·54	5·91	5·36	5·73	6·85
Birtley	5·50	5·56	5·63	5·62	5·79
Average	5·31	5·54	5·25	5·40	5·67

In comparing the effect on the variation in composition of the swedes due to manures deficient in some particular ingredient, it is noticeable that there is little to choose between one manure and another, but if any particular element of manure is more necessary than another, it is the phosphates. The manures containing no phosphates produce on the whole a swede containing less sugar and less total dry matter than those manures deficient in potash and nitrogen.

The beneficial influence of phosphates for manuring the swede crop is therefore slightly underestimated in the usual manurial trials.

But it is very evident that the effect of manure on the composition of swedes is much less than the effect of variety or soil. In other words it is the choice of variety rather than the choice of manure that affords the farmer a good control over the quality of his crop.

Uniformity of Composition.—

In addition to heavy cropping and high quality, uniformity is also a desirable characteristic in any variety of farm produce.

The stations producing the crop most uniform in composition were:—

Medomsley E.	(Green top Swede)
Birtley ...	(Best of All)
Newlands Haugh	(Best of All

The yield per acre at Birtley (see p. 127) shews that the manures produced large changes in the amount of swedes grown, hence the uniformity is due to the variety and not to the soil. At Cockle Park X.L All was found to be the variety least subject to variation. There appears to be no doubt that uniformity and sweetness is a characteristic of this variety.

Relation of Quality to Quantity.—

If the yield per acre and the percentage of dry matter be compared between the different plots at any one station (see pp. 104 and 127) it will be seen that at those stations where the crop is uniform in quantity it is uniform in quality also; that a small crop generally means a crop of high feeding value and a large crop one of low feeding value.

For example, at Medomsley E., Newlands Haugh and Birtley the quantity and quality are alike little affected by manures; at Cleatlam, Neasham Grange, Medomsley W. and Sherburn, both quantity and quality are alike very variable.

Modification of Results of Field Experiments.—

The large differences in the chemical composition of the swede crop shew that in order to know the real feeding value of a crop, account must be taken of its composition.

In a ton of swedes there are from 17½ to 18½ cwt. of water. The gross weight of the swede crop is therefore mostly water; to prove that a certain system of manuring yields a heavy crop is only to shew the way to grow water. If the crop, however, be analysed, it is possible to find out how much food is produced per acre.

On page 145 is given in tabular form the yield per acre of swedes together with the calculated yield of dry matter (*i.e.*, food stuff) per acre on seven different farms under five different systems of manuring. As a general rule the total food in a crop varies with the gross weight of that crop; when the gross weight is heavy the total amount of food is great and so on. But where two plots give results which are not very different, we often find that the plot which gives the larger gross weight gives the smaller amount of food.

To take individual cases on page 145.

Cleatlam.—The gross weight of crop at this station would lead us to conclude that the omission of nitrogen or potash from the manure causes the serious diminution in the crop of about a ton and a half, but the actual yield of dry food stuff is only one or two cwt. of dry stuff equal to about 9 or 18 cwt., respectively, of average swedes. That is to say, the beneficial effect of nitrogen and potash at this station is much less than the gross weight of the crop would lead us to suppose.

Medomsley W.—The gross weight of the crop would lead us to suppose that the omission of potash causes a loss of two tons of swedes per acre, whereas the actual food stuff per acre is very slightly more where no potash is used. The difference is, however, well within experimental error, and the conclusion we must draw is that a potash manure is useless on this soil.

Newlands Haugh.—The gross weight of the crop at this station would give the impression that manures containing no potash or no phosphates actually reduced the crop. The yield of real food per acre, however, shews us that such manures do produce a slight increase in the crop, not sufficient to justify the expense of the manure. Without taking into account the composition of the swedes, the results of this experiment appear improbable, but when allowance is made for the water in the crop, the results are perfectly reasonable.

Sherburn.—The gross weight of the crop would lead us to suppose that of the three incomplete manures, that which lacked nitrogen was the worst, whilst the actual food stuff produced on those three plots teaches us that it is the manure deficient in phosphates which gives the poorest return, a result much more in conformity with general opinion.

Sugar Swedes.—

As stated in the Annual Report for 1900, p. 180. An attempt has been made to breed up swedes to a high percentage of sugar. Naturally any such experiments are extremely slow, and several years must elapse before any results can accrue. Owing to the fact that all the swedes did badly at Cockle Park, in the season under comment there is little apparent progress, but a few swedes of an exceptionally high degree of sweetness have been reared and most of the poorest eliminated.*

Mangels.—

A crop of mangels was grown at Cockle Park. They contained only 9·98 per cent. of dry matter. Although it would not be fair to introduce comparisons as the result of a single analysis it is certainly noteworthy that the mangels should contain more water than swedes.

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* Since writing the above, I have noticed that those swedes which contain most sugar bear the most vigorous shoots. If this be generally true, the improvement of the quality of swedes lies entirely under the farmer's own control. If a farmer lets three or four times as many swedes go to seed as are required, and, just before flowering, pulls up all the poorer ones and lets run to seed only those that produce the most vigorous shoots, then his seeds will all have come from swedes of high quality. This seed will produce roots of greater feeding value than seed grown in the usual way.

Potatoes.—

This season an experiment has been carried out to test the relationship between chemical composition, cooking qualities, manuring and district in the potato crop. Table XIX. gives the amount of dry matter in potatoes grown in the districts named with 15 different manurial dressings.

It will be seen that a manure containing no potash gives a potato with most dry matter and that a manure containing no nitrogen stands second.

Where the manure contained no potash the crops were very small in amount, to which fact the high proportion of dry matter is due.

Of the 3 potash manures kainit always yields the most watery potatoes and as a rule the sulphate yields the driest.

In the table below the cooking quality and chemical composition of several varieties of potatoes grown at Cockle Park is given. There appears to be little relationship between composition and cooking quality.

RELATION OF COOKING QUALITY TO CHEMICAL COMPOSITION IN POTATOES.

Plot	Name.	Cooking Quality.	Dry matter.
			Per cent.
2	British Queen... ...	Good to very good ...	24·15
3	Sutton's Supreme ...	Poor	26·75
4	,, Abundance...	Very fair	23·22
5	Challenger	Fair	26·97
6	Findlay's Eighty Fold	Very fair	27·48
7	Reading Russet ...	Very fair	27·10
9	British Lion	Good to very good ...	27·33
10	General Kitchener ...	Very fair	25·81
11	Dean Kitchen... ...	Poor	25·35

Farmyard Manure.—

Eight samples of farmyard manure have been analysed this season, the results being set out in tabular form in Table XXII., p. 149.

It will be seen that there is hardly any important difference between the manure made by cattle whether they are eating a full or a half ration of roots.

As regards methods of storage the manure stored in cement pits has proved to have a lower value weight for weight than that stored on the ground. The higher percentage of mineral matter in the manure stored on the ground is due to admixture of earth, and the lower percentage of water to loss by evaporation. The superior value of the manure kept on the ground is most evident in the amount of potash, which is the most soluble constituent and the one most likely to be lost by drainage. The two former seasons have shewn that manure stored in the cement pits loses 20 per cent. of its valuable constituents by drainage; this season's tests merely confirm the inefficiency of these cement pits.

Soils.—

The soils analysed during the past season comprise the following:—

Shield Ash.

The results set out in Table XX. shew that the two plots are of a naturally different character. In Plot 1 the surface soil is heavier than the sub-soil, whilst in Plot 11 the reverse is the case. Plot 11 is very much richer than Plot 1, the difference being too great to attribute to any treatment the land has recently received.

Kimblesworth.—

The analysis shews that this soil is deficient in both potash and phosphoric acid. The complete results are set out in Table XXI.

Rose Bank.—

The chemical and physical composition is set out in Table XXI., from which it is clear that the soils are deficient in both potash and phosphoric acid.

They are very uniform in general character and seem very suitable for experimental purposes.

The estimations of iron, lime and silica soluble in citric acid were undertaken as preliminary to some more extended investigations which will have to be postponed till a later report. In the meantime it is interesting to note that the application of a complete dressing of artificial manure to Plot 1 has depressed the lime soluble in citric acid to a considerable extent.

POT EXPERIMENTS.

The Absorption of Arsenic by Barley.

This investigation was originally designed to observe in what forms and in what way arsenic was absorbed by plants, and what influence, if any, the supply of phosphates had on this absorption; but the investigation had to be modified during its course owing to the unexpected occurrence of arsenic in the soil used. Whilst the experiment must, therefore, be considered in some respects a failure, yet many points of interest have occurred worth noting.

A set of six 10-inch pots were used, being manured respectively with (1) nothing; (2) arsenious acid; (3) arsenic acid; (4) superphosphate; (5) superphosphate and arsenious acid; (6) superphosphate and arsenic acid. The arsenic being in all cases equal to 11 lb. of arsenic (As_2O_3) per acre, and the superphosphate equal to 170 lb. of phosphoric acid (P_2O_5) per acre. The plots were planted with tares and barley, the former reaped green and the latter thinned in July; the barley gathered in September and divided into (1) bottom half of straw; (2) top half of straw; (3) ears and chaff; (4) grain. Samples of soil were also taken after the close of the experiment. The amount of arsenic in the soil quite overwhelmed the amounts added artificially, so that the effect of their addition was not evident.

As regards distribution of arsenic most of the arsenic occurred in the grain and not in the stalks or leaves.

The College garden soil contained arsenic equal to 30 to 50 lbs. of white arsenic per acre to a depth of 8 inches.

Other samples of barley and some swedes grown in the garden also yielded similar quantities of arsenic.

Similar experiments are in progress for the coming season which when completed will add much information on the subject.

Electric Current on Soil.—

A short experiment was carried out to determine what effect was produced on crops by passing an electric current through the soil on which they were growing. Three boxes two feet long by 8 inches wide were filled to 6 inches depth with poor sandy soil, sown with barley and watered at intervals. One had an alternating current of 110 volts passed through, the second a continuous current of 12 volts and the third no current at all. The amount of current passing was very small, being about ·20 ampère with the alternating current; the current was only switched on for short periods at a time. The unelectrified box grew barley fairly well, the box with 12 volt continuous current only produced barley of half the height, and the box with 110 volts alternating current hardly produced any barley plants at all.

It is clear from these experiments that neither root stimulation nor soil electrolysis can, under the above conditions, be anything but harmful.

COMMERCIAL PRODUCTS.

Foods.—

The composition of the foods used at Cockle Park are given in Table XXIII. The general tendency of all foods has been to rise greatly in price and to fall off slightly in quality.

Linseed cake No. 363 contained rather much grit, starch and spurrey, though undoubtedly it was of a high class as regards composition.

Several samples of decorticated cotton cake were examined for oil only and were found to range from 9·00 to 12·41 per cent.

The oat-dust was relatively cheap; owing to its good feeding value it has been used in increased amount.

The treacle used at Cockle Park was of good quality containing 39·27 per cent. of cane sugar and 19·10 per cent. of "invert" sugar.

Manures for Cockle Park.

Besides old stock (see Report 1900, p. 232) the new manures that were analysed comprise a superphosphate of 30·14 per cent. phosphate of lime rendered soluble, a sulphate of ammonia of 96·65 per cent. purity and a nitrate of soda of 96·88 per cent. purity.

Several samples of basic slag were tested for fineness before purchasing; 72 to 87 per cent. being the range of the different makes. The one actually purchased was found to be 80 per cent. fine and to contain 37·40 per cent. phosphate of lime.

Some sulphate of potash that was ordered was found, on examining the sample sent, to be a chloride (muriate) and not a sulphate at all. On a further examination of the bags as actually delivered three distinct kinds were found, namely, a white, a mottled, and a pink variety, which on being tested were found to contain 37, 34 and 20 per cent. of pure potash respectively; the original sample containing 34·70 per cent. As the material was only guaranteed to be 30 per cent. there was no real cause for complaint on the score of not getting our money's worth.

Lime

is a material of considerable importance in the field experiments, but, owing to its nature of absorbing both water and carbonic acid from the air, presents considerable difficulties in dealing with it so as to allow the calculated amount of real lime per experimental area. In the first place lime is bought by the weight it has at the kiln and hence it is necessary to know its original kiln composition before instituting any comparison between the lime of one kiln and that of another. In the second place it is necessary to know its composition after slaking, in which state it is usually applied.

As regards the first point I have found that lime which had been stored in a heap under cover some years was *fully* slaked but contained little carbonic acid. In the calculations in connection with the field experiments we have therefore assumed the amount of carbonic acid to be constant and the water variable.

This brings the original percentage of lime at the kiln to be:—

	Per cent.
Little Mill	76·70
,, ,, ground	79·77
Fourstones	74·72

which leaves little to choose between them. (Compare Report 1900, p. 232.)

In order to find out whether it was possible to calculate what the weight of the lime would be after slaking, the purest, namely, Little Mill ground lime, was tested both on the large scale at the farm and on the small scale in the laboratory with the following results:—

100 parts lime as sampled at time of analysis absorb
22·81 parts of water (theory).
20·70 ,, ,, (laboratory experiment).
18·79 ,, ,, (farm experiment).

The lime always contains some silicate of lime which will not absorb water, consequently the theoretical calculation is rather high, though near enough for practical purposes.

Manures for County Experiments.—

The manures submitted to analysis were three superphosphates containing 27·72, 33·54 and 33·21 per cent. of phosphate of lime rendered soluble, one sulphate of ammonia and one nitrate of soda being 97·22 and 97·43 per cent. pure respectively and one sample of sulphate of potash containing 49·35 per cent. pure potash equal to 91·32 per cent. of sulphate of potash.

In addition to the above some of the manures still left in stock from last year were used in the Experiments (see Report 1900, p. 233).

EXPERIMENTS CARRIED OUT AT THE CUMBERLAND AND WESTMORLAND COUNTY COUNCIL FARM, NEWTON RIGG, PENRITH, DURING THE YEAR ENDING, JANUARY 31st, 1902.

(W. T. Lawrence.)

Manuring of Meadow Hay.

The 6 plots were dressed as shewn in the following table in 1898, and received no further manuring in 1899 and 1900. Last year (1901) they were again manured as in 1898, but with very different results, the season being one of the worst

Plot.	Manure per Acre.	Crop in 1898. per acre.	Crop in 1901. per acre.
1	No manure	32 cwt.	16 cwt.
2	10 tons dung	49 „	26 „
3	¾ cwt. nitrate ... ... 1½ cwt. kainit ... ... 3 cwt. basic slag	49 „	20 „
4	¾ cwt. sulphate of ammonia 1½ cwt. kainit ... ... 3 cwt. basic slag	44 „	20 „
5	¾ cwt. nitrate ... ... 1½ cwt. kainit ... ... 3 cwt. superphosphate ...	53 „	20¼ „
6	¾ cwt. sulphate of ammonia 1½ cwt. kainit ... ... 3 cwt. superphosphate ...	45 „	22 „

on record for meadow hay. The general lessons of the first three years were (1) that well blended artificials may beat dung in the year of application, (2) that dung wins very decidedly the next year, but (3) in the third year the residues are nearly alike. For the sake of comparison the yields of the two years in which the plots were manured are given.

It will thus be seen that in all the plots dressed with artificials last year, the crops were less than half of what they were in 1898; and that the yield of the dunged plot, though far below that of 1898, is both relatively and absolutely much better than the artificially dressed ones. Yet at £5 per ton (the high price at present ruling for good meadow hay), the artificials have paid, for 20s. worth of extra hay has been produced (compare Plot 1 with the others) for an outlay of about 17s.

Varieties of Oats.

Plots of ¾ of an acre each were sown with Hamilton, Garton's Waverley, Goldfinder, and Tartar King, without manure, after a heavy swede crop carted off. The extreme drought prevented the straw reaching its wonted length, but each variety was well eared with well-matured corn. The results are as follows:—

	Hamilton.			Waverley.			Goldfinder.			Tartar King.		
	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.
Corn per acre	19	0	15	20	3	24	21	3	17	23	2	5
= bushels of 3¼ stones	47·1			51·6			54			58		
Straw per acre ...	18	2	8	18	0	16	20	0	8	18	0	11
Oatmeal from 26 stones	16½ stones			15 stones 1 lb.			14 stones			14 stones		
= Oatmeal per acre ...	97·1 stones			97·4			94·4			101·4		

It will be at once seen that Hamilton stands lowest for yield of corn, and Tartar King highest; on the other hand

Hamilton stands first for percentage yield of oatmeal, which is really the true test of the food value of oats, and Tartar King in company with Goldfinder stands lowest; and when the straw yield is also taken into account, there seems little to choose between one variety and another. The superior foddering qualities of Hamilton and Waverley straw, combined with their good mealing qualities should recommend them for home consumption.

Varieties of Potatoes.

The potato crop was the crop of the year; but coming after a good turnip crop fed on by sheep, the land was too rich for manurial experiments; the trials were therefore mainly between different varieties. All but four drills were sprayed with the Bordeaux mixture to prevent disease, and four drills of the "Up-to-date" variety received at the rate of 2 cwt. of kainit to the acre in addition to the light dressing of dung given to the whole crop. The results are as follows:—

Plot.	Variety.	Yield per acre.		
		Tons.	Cwt.	
1	Farmers' Glory	15	7	sprayed.
2	Scottish Triumph	14	19	"
3	Lord Dufferin	12	10	"
4	Cecil Rhodes	13	18	"
5	Duchess of Buccleuch ...	14	10	"
6	Duke of Fife	11	10	"
7	General French	13	18	"
8	British Queen	12	8	"
9	Up-to-date	16	4	"
10	Do.	14	12	unsprayed.
11	Do.	12	2	sprayed but dressed with kainit.

There was practically no disease either in the sprayed or unsprayed potatoes, but the effect of spraying seems to have been to increase the crop by 1½ tons to the acre (see "Up-to-date," Plots 9 and 10). The most remarkable feature of these experiments is the comparatively poor yield of the plot dressed with kainit—a potash manure which has been hitherto markedly effective. The heavy yields of the other plots shew that there was no deficiency of potash in this soil, and under these circumstances it is probable that in such dry weather as prevailed the salt in the kainit acted as a serious check to the potato plant. Here as in most other places "Up-to-date" came out at the top.

Mangels.

The mangel crop was also grown after turnips fed on with sheep, consequently the land was deemed in too good condition for ordinary manurial trials. The crop received the light dressing of 10 tons of dung in the drills, and all but two drills were top-dressed with 1½ cwt. of nitrate of soda to the acre after "singling."

The nitrate-dressed crop weighed 33 tons 2 cwt. to the acre; the two drills without nitrate weighed 29 tons 17 cwt. to the acre; so that the top-dressing proved very profitable even though the land was in "good heart."

Swedes.

The swede crop of 1901 was all under experiment, but not, as in other years, for the sole purpose of determining the relative effects of different manurial dressings, but as a part of a Five-years' Rotation Experiment, of which it formed the first crop. The artificial dressings used are those that have proved most profitable in previous years. So far as this particular crop is concerned the plots show the results of dung (1) all ploughed in at the "back-end," (2) half ploughed in and half reserved for the drills, and (3) all applied in the drills; the comparative effects of nitrate of soda and sulphate of ammonia, and of superphosphate and basic slag.

Plot.	1901. SWEDES.	1902. OATS.	1903. SEED-GRASS HAY.	1904. GRAZED.	1905. OATS.
1	6 t. dung ploughed in, and 6 tons in drills. 21 tons, 19 cwt. Fed on with sheep.				
2	1 cwt. nitrate 2 „ kainit 5 „ superphos. 24 tons, 4 cwt. Fed on with sheep.				
3	1 cwt. nitrate 2 „ kainit 5 „ superphos. 24 tons, 1 cwt. All carted off.	½ cwt. nitrate ½ „ kainit 1 „ super.	½ cwt. nitrate 1 „ kainit 2 „ super.		
4	1 cwt. nitrate 2 „ kainit 5 „ superphos. 22 tons, 6 cwt. All carted off.				
5	1 cwt. nitrate 2 „ kainit 5 „ basic slag 23 tons, 6 cwt. All carted off.	½ cwt. nitrate ½ „ kainit 1 „ slag	½ cwt. nitrate 1 „ kainit 2 „ slag		
6	1 cwt. sulph. amm. 2 „ kainit 5 „ slag 21 tons, 15 cwt. All carted off.	½ cwt. amm. ½ „ kainit 1 „ slag	½ cwt. amm. 1 „ kainit 2 „ slag		
7	No manure 15 tons, 11 cwt. All carted off.				
8	6 tons dung and ½ cwt. nitrate 1 cwt. kainit 2½ „ superphos. 21 tons, 5 cwt. All carted off.		½ cwt. nitrate ½ „ kainit 2 „ super.		
9	12 tons dung in drills 22 tons, 10 cwt. All carted off.				
10	12 tons dung ploughed in 19 tons, 11 cwt. All carted off.				
11	6 tons dung ploughed in and 6 tons in drills 21 tons, 14 cwt. All carted off.		6 tons dung		

The season was one of the driest known, but the crop was an even one in brairding, and progressed well until the end of September, when it was checked in its further growth by an attack of mildew brought on by the September drought. The table on preceding page gives the results of the swede crop, and the general scheme of the whole Rotation experiment. The plots measure half an acre each, but the manurial dressings and yields are given per acre.

It will be noticed (1) that on the whole the artificial dressings have done better than dung, which has not often been the case in former years; (2) that 12 tons of dung in the drills has beaten the same quantity, half ploughed in and half placed in the drills, and greatly beaten 12 tons all ploughed in (compare Plot 9 with 1, 11, and 10); (3) that as in former years there is little difference in the yields where superphosphate and basic slag are used as sources of phosphoric acid (compare Plots 2, 3, and 4 with 5); (4) and again as in former years sulphate of ammonia fails to come up to nitrate of soda as a source of nitrogen to the swede crop on this land (compare Plots 5 and 6). The unmanured plot has produced a much heavier crop this year than in former years; this may perhaps be accounted for by the more abundant formation than usual of nitrates in the soil during the past hot summer, for it was during the later summer months that the crop on Plot 7 so much improved.*

Sheep-feeding Experiments.—

On December 3rd, 48 cross-bred Cheviot and Border-Leicester hoggs were divided into three lots of 16 each, and weighed. Lot 1 was penned on the swede land to consume one-third of an acre of swedes. Lot 2 was similarly placed; but Lot 3 was placed on a bare grass field to consume the swedes off one-third of an acre. The acre of swedes weighed 23 tons, and they were cut and served to the sheep twice a day. The swedes lasted Lots 1 and 2 fifty-four days, practically eight weeks, but Lot 3 had at the end of this period about 1 ton still unconsumed. All had hay *ad lib.*, in addition to which Lot 1 received ¼ pound of decorticated cotton cake, and ¼ pound Indian corn per head per day; Lot 2 the same weights of linseed cake and oats; and Lot 3 of linseed cake and Indian corn. At the end of 24 days they were again weighed and the corn to each lot was then doubled, the cake remaining as before; Lots 1 and 3 readily ate the extra Indian corn, but Lot 2 would not eat their extra oats, and so were fed as at first. On January 27th, that is, 30 days later, or 54 from the commencement, the sheep were again weighed, killed, dressed, and sold by weight in the London Central Meat Auction Market; but it should be mentioned that mutton prices were ruling very low at the time. The following table gives the particulars:—

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* Compare with remarks on p. 13.

		LOT 1. Cotton cake, maize, hay, and swedes.	LOT 2. Linseed cake, oats, hay, and swedes.	LOT 3. Linseed cake, maize, hay, and swedes on grass.
		lbs.	lbs.	lbs.
1	Weight at first ...	1,568	1,531	1,552
2	Gain in 24 days ...	226	225	162
3	Gain per head per week	4 fully	4 fully	3 nearly
4	Gain in next 30 days	84	52	176
5	Gain per head per week in these 30 days ...	1¼ nearly	¾ fully	2½ fully
6	Total gain per head in 54 days	19·4	17·3	21·1
7	Total live weight ...	1,878	1,808	1,890
8	Total dressed weight	944 & 96 of fat	942 & 97 fat	955 and 90
9	Percentage of dressed weight to live weight exclusive of fat ..	50¼	52	50½
10	Prime cost each ...	23s. 0d.	23s. 0d.	23s. 0d.
11	Selling price net ...	33s. 10½d.	34s. 8½d.	34s. 10d.
12	Gross profit	10s. 10½d.	11s. 8½d.	11s. 10d.
13	Food consumed per head	12¾ lb. c. cake 19½ lb. maize 32 lb. hay 9½cwt. swedes	12¾ lb. l. ck. 12¾ lb. oats 32 lb. hay 9½ c. swedes	12¾ lb. l. ck. 19½ lb. maize 29 hay 8¼ c. swedes
14	Value of food at present high prices ...	5s. 6d.	5s. 2d.	5s. 1d.
15	Net profit per head ...	5s. 4½d.	6s. 6½d.	6s. 9d.

The cakes (American) were bought in the summer at £7 a ton, the maize cost 9½d. a stone, the oats are valued at 24s. a quarter (26 stones), hay at £5 a ton, and swedes at 4s. 7d. a ton consumed on the land. A considerable profit, over and above that shown in the Table, lies in the high prices obtained for the home-grown hay and oats, and in the manurial values of all the foods consumed.

The first point to be noticed is the great rapidity with which the sheep, especially Lots 1 and 2, put on weight during the first 24 days (December), and the very slow increase of Lots 1 and 2 afterwards. The former period was frosty and dry, a thin coating of frozen snow covering the ground; the latter period was very wet, bitter westerly winds prevailing, to which Lots 1 and 2 were exposed without shelter, and it was with difficulty they could move in the mud; Lot 3 was on a dry grass field with a west wall for shelter, and consequently progressed steadily to the end, ultimately making the best weight. This is the first winter that sheep on grass have really fattened quickly, but this winter they have had cut swedes served them instead of yellow turnips thrown on the pasture, and the weather was such as to tempt them but little to wander much for a picking of grass. Still the grass seems to have saved the hay and swedes a little. Lot 1 ate the most hay during the first period, but Lot 2 ate much more than the other two lots, who had their maize doubled, during the second period.

Another noticeable point is that of the better killing of Lot 2 receiving oats than of Lots 1 and 3 receiving maize (see 7, 8, and 9). There appears to have been but little difference in the feeding values of cotton and linseed cakes, and no advantage in increasing the maize during the later stage of fattening. A good sheep in Lot 1 died suddenly, a day after the experiment was ended, probably through a sudden chill; for purposes of comparison of the lots, its dressed weight was taken to be that of the average of the others of the same lot.

APPENDIX.

TABLE I.—RAINFALL AND SUNSHINE AT COCKLE PARK, MORPETH, IN 1900 AND 1901.

Month.	Rainfall.		Sunshine.	
	1900. Inches.	1901. Inches.	1900. Hours.	1901. Hours.
January, first half	2·615	0·565	30·0	0·0
,, second ,, ...	1·005	1·360	20·9	3·6
February, first ,, ...	1·825	0·795	39·8	41·0
,, second ,, ...	3·910	1·050	32·5	18·9
March, first ,, ...	·626	1·480	39·4	52·7
,, second ,, ...	1·645	0·910	52·3	83·7
April first ,, ...	1·315	0·475	71·8	95·7
,, second ,, ...	·240	0·590	81·1	110·4
May first ,, ...	·855	0·620	70·9	138·8
,, second ,, ...	·490	2·790	77·9	107·3
June first ,, ...	1·285	0·305	99·9	150·1
,, second ,, ...	2·865	1·220	78·1	104·1
July first ,, ...	1·520	0·505	104·4	150·2
,, second ,, ...	·445	2·135	96·2	94·6
August first ,, ...	3·380	1·170	87·1	88·9
,, second ,, ...	2·030	1·330	32·4	114·0
September first ,, ...	·360	·165	95·7	88·4
,, second ,, ...	·425	·921	67·6	54·6
October first ,, ...	2·375	1·030	71·9	53·0
,, second ,, ...	3·680	1·040	41·2	45·5
November first ,, ...	2·045	3·060	23·9	48·9
,, second ,, ...	1·925	1·864	15·2	38·0
December first ,, ...	1·175	·984	18·2	27·8
,, second ,, ...	0·817	3·392	5·2	29·0
Total	38·853	29·756	1353·6	1739·2

TABLE II.—EXPERIMENTS ON SWEDES.

PLOTS $\frac{1}{27}$-ACRE; $\frac{1}{40}$-ACRE WEIGHED. FIGURES PER ACRE.

Plots.	Manuring per Acre.							Cost of Manures.		Glower o'er 'em, Sedgefield.		Sands Hall, Sedgefield.		*Howley Hope, Sedgefield.		*Newlands Haugh, Ebchester.		East Farm, Medomsley.		West Farm, Medomsley.		Sherburn Colliery.		*Birtley.		*Cleatlam, Staindrop.		Neasham Grange, Darlington.		High Bradley, Medomsley. (Yellow turnip.)		Average of Seven Stations.		Profit. Turnips @ 8/- Per Ton.	
	Dung.	Sulp. Ammon.	Nitr. Soda.	Super.	Slag.	Prec. Bone Phos.	Kainit.																												
	Tns	C.	C.	C.	C.	C.	C.	s.	d.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	s.	d.
1	..	⅜	½	3½	..	..	2	21	3	20	1½	12	0	15	4¼	22	3¼	16	15	20	10	20	1½	19	11	12	15¼	20	4¼	16	12½	18	0¾	33	3
2	..	¾	1	7	..	..	4	42	6	22	8¼	15	0	19	4	28	1½	17	10	21	10	22	8¼	20	6	16	0¾	22	2½	22	0	20	11¼	32	0
3	..	¾	1	..	5	..	4	36	6	18	1¾	12	19	20	5	25	1½	18	0	19	13½	18	1¾	17	15¾	15	12¾	20	13½	20	0	18	4	19	0
4	..	¾	1	..	..	2	4	37	9	21	16	12	12¼	20	3¼	25	6½	18	15	18	7½	21	16	17	18¼	16	15¾	22	2½	22	12½	19	14½	30	3
5	..	..	..	7	..	..	4	25	6	19	10	10	0	15	11	27	2¾	18	15	16	0	19	10	15	18½	14	10¼	22	7¾	20	18½	18	3	29	6
6	..	¾	1	..	..	..	4	25	0	19	14¾	11	6½	14	1½	21	14¼	19	15	12	10¾	19	14¾	14	4	6	6½	11	4	2	12½	15	5½	7	0
7	..	¾	1	7	..	..	..	34	3	20	4	12	9	13	1	21	12½	18	0	20	10	20	4	12	19¼	14	8½	20	5¼	20	10¾	18	17½	26	9
8	..	..	..	..	..	..	..	..	..	14	17½	9	7½	16	0	23	1½	15	10	6	14¾	14	17½	11	15	9	3¼	11	17¼	5	10	11	5	..	..
9	18	..	..	..	..	..	..	45	0	19	5	16	0	22	10	27	9¼	21	7½	14	16½	19	5	20	17¼	13	18½	19	4	24	0	19	2½	18	0
10	12	..	..	..	..	..	..	30	0	21	14	16	15¼	22	0	29	8¼	17	5	14	0	21	14	13	8½	8	9¾	20	4	24	3¼	19	8	35	0
11	12	⅜	½	3½	..	..	2	51	3	22	8½	17	12¾	22	5¾	30	11½	20	10	18	6½	22	8½	17	15¼	14	6	21	6¾	23	13½	20	18	25	9
12	12	..	..	3½	..	..	2	42	9	21	9¾	14	14¼	15	0	26	5¼	20	0	14	17½	21	9¾	18	9¾	15	18¼	23	2½	23	12½	19	18	26	3
13	12	⅜	½	..	..	..	2	42	6	21	10¼	16	12¾	16	3¼	25	18½	19	10	19	5	21	10¼	17	16	15	18½	23	12½	22	0	20	11½	32	0
14	12	⅜	½	3½	..	..	..	47	3	22	8¼	18	0	22	4¼	29	12½	18	5	21	4¼	22	8¼	19	4	18	18½	24	5	21	7½	21	2½	31	9
15	12	..	..	3½	..	..	..	38	9	19	5	17	14	21	0	28	8¼	18	0	19	15¾	19	5	20	10	15	0	24	2¼	19	13¼	19	13½	28	9

NOTE.—Standard dressing 35 lbs. nitrogen, 100 lbs. phosphoric acid, and 50 lbs. potash per acre to Plot 2. The percentage composition of the mixture used on Plo was nitrogen 2·8 °/ₒ (= ammonia 3·4 °/ₒ), phosphoric acid 8·0 °/ (= tribasic phosphate of lime 17·44 °/ₒ), potash 4 °/ₒ.

* Excluded from average.

TABLE III.—EXPERIMENTS ON POTATOES.

PLOTS $\frac{1}{27}$-ACRE ; $\frac{1}{40}$-ACRE WEIGHED. FIGURES PER ACRE.

Plots.	Manures applied per Acre.							Cost of Manures.		Sherburn Colliery (Broomside House).		Sherburn Colliery (Byers Garth).		Gosforth (Blakelaw Farm).*		Neasham (Neasham Grange).*		West Cornforth (Brandon House).		Sedgefield (Sands Hall).		Sedgefield (Diamond Hall).		Riding Mill (Broomhaugh).		Acklam. (Sycamore Grove).*		Average of Six Stations.					Profit, Ware and Seconds at 50s. per ton.	
	Dung.	Sulph. amm.	Nit. of soda.	Super.	Sulp. of potash.	Muriate.	Kainit.																					Ware		Sec'nds.		Small.		
	T.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	s.	d.	T.	cwt.	T.	cwt.	T.	cwt.	T.	cwt.	T.	cwt.	T.	cwt.	T.	cwt.	T	cwt.	T.	cwt.	T.	cwt	T.	cwt.	Cwt.	£	s.
1	18	...	...	...	...	...	...	45	0	11	11½	13	13¾	11	7¼	11	14	11	1½	18	8½	8	10¾	11	2¼	11	7¼	11	4¼	1	4	9¼	16	9
2	12	...	...	...	...	...	...	30	0	11	19	11	11¾	10	11½	12	14½	9	9	15	18½	7	2½	9	17¼	11	10	9	14¾	1	5	7	13	13
3	12	$\frac{7}{16}$	$\frac{9}{16}$	1¾	$\frac{11}{16}$	...	...	49	0	11	18¼	11	11½	10	4½	13	14¾	9	14¼	16	2½	7	9	10	5¾	11	10	10	0¼	1	3½	7¾	13	4
4	12	⅞	1⅛	3½	1⅜	...	...	68	0	9	13¼	13	9	12	14½	13	7	10	12	16	4¾	8	12	11	2	11	10	10	13	0	19¼	6¾	13	6
5	...	⅞	1⅛	3½	1⅜	...	...	38	0	6	8¼	7	18	12	2¾	13	18¾	8	13	9	14¼	6	11½	9	8	10	0	6	18½	1	3¾	7½	6	1
6	...	3½	...	3½	1⅜	...	...	51	9	6	17½	7	5	13	16	15	0½	10	2	9	12¾	7	0	8	16½	10	4¼	7	1	1	4¾	8	5	16
7	...	...	4½	3½	1⅜	...	...	64	0	7	7¼	9	0	12	2¼	14	3	6	6	11	6¾	5	14½	9	8¼	9	2¼	7	9¾	0	19¾	6	5	13
8	...	⅞	1⅛	7⅛	1⅜	...	...	49	6	6	11½	7	12¾	10	19¼	14	16¼	8	10	10	0	6	18	9	1½	8	7¾	6	17	1	5¼	8	5	10
9	...	⅞	1⅛	3½	2¾	...	...	45	6	7	2¾	9	12¾	9	13½	14	19¾	8	4	11	18¼	7	0	10	9½	8	15	7	19	1	2	7½	8	1
10	...	⅞	1⅛	3½	...	2	...	48	0	10	3½	9	16¾	10	18	15	0½	8	1	12	7½	7	4½	9	11¾	10	15	8	12	0	18¾	7	9	3
11	...	⅞	1⅛	3½	...	...	6¾	46	9	8	5¾	9	13½	10	12¾	14	0½	7	14¾	11	9¼	6	7¾	9	8½	9	19¼	8	0½	0	16	5¾	7	8
12	...	...	...	...	..	..	...	...		2	16	4	1¾	9	1½	11	15¼	4	5	8	1¼	3	17¾	6	9½	7	2	3	13½	1	5	8	...	
13	...	...	...	3½	1⅜	...	...	18	3	4	14¾	6	0¾	8	4¼	13	4¼	7	2½	8	11¼	5	3½	8	9	10	3	5	11½	1	2½	8½	3	10
14	...	⅞	1⅛	...	1⅜	...	...	27	3	6	19¼	6	7¼	9	10¼	13	5¾	7	12¾	10	4¼	5	4¾	8	13¼	9	6¾	6	9¼	1	1	7	5	2
15	...	⅞	1⅛	3½	...	...	...	30	6	4	2½	2	17¾	9	9¼	13	2¼	4	12½	9	2½	4	10	6	9½	8	7¾	4	6½	0	19¼	9	Loss	11

NOTES.—The standard dressing of artificials applied to Plot 5, etc , contained per acre:—Nitrogen, 40 lbs. ; Phosphoric Acid, 50 lbs. ; Potash, 50 lbs.

The crops of stations marked * have been excluded from the average.

The profit has been calculated by valuing the increase on the manured plots over the unmanured plots at 50s. per ton, and deducting the cost of the manure. Ware and Seconds only have been valued.

The figures under each farm give the crop of Ware and Seconds. The small potatoes passing through a 1¼ inch riddle have been omitted. The quantity was proportionate to the saleable crop, except on Plots 12—15. The average quantity of the small potatoes has been given in the table.

TABLE IV.—EXPERIMENTS ON SEEDS HAY.

PLOTS $\frac{1}{20}$-ACRE. FIGURES PER ACRE.

Plots.	Artificial manures.				Cost of artificials.	Byers Garth, Sherburn.		Springs House, Birtley.		Hesledon.		Diamond Hall, Sedgefield.		Low Bradley, Medomsley.		West Farm, Medomsley.		Newlands Haugh, Ebchester.		Hall Farm, Sherburn Colliery.		Manor Farm, Usworth.		AVERAGE.					
																								Eight series of Plots.*			Eleven series of Plots.†		
	Sulp. of ammonia.	Nitrate of soda.	Super.	Muriate of potash.		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	Yield.	Increase due to manure.	Profit hay at 60/- per ton.	Yield.	Increase due to manure.	Profit hay at 60/- per ton.
	cwt	cwt	cwt	cwt	s. d.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	s. d.	cwt.	cwt.	s. d.
1	—	—	—	—	—	48½	46¾	34¼	36¼	46½	55½	26	23¼	39¼	43¾	30	25¾	53¼	48	41½	42	66	62¼	36¾	—	—	38¾	—	—
2	1½	—	—	—	16 9	66¾	61	46	51¼	61¾	65¾	44½	48	56½	52	42	41	61	52¾	56½	59¾	67¾	74½	50¼	13½	23 9	52½	13¾	24 6
3	—	2	—	—	17 9	52¾	50½	44¾	47¾	57¾	67¾	36¼	37¼	54½	54	45¼	38	59	55½	55¾	64½	62¼	66¾	47½	10¾	14 6	—	—	—
4	¾	1	—	—	17 3	64¾	59½	44½	48½	59¾	62¾	43¼	40½	56½	53½	36¾	42	62¾	61½	49¾	67¼	58	60¼	50½	13¾	24 0	—	—	—
5	—	—	3½	—	10 6	58½	58¼	34	44½	46¾	52¼	26¼	28¼	47¼	44	36	22	55¼	56¾	44¾	62¼	59	51½	39¼	2½	3 0	—	—	—
6	—	—	—	¾	6 0	50½	56	38¾	37¼	54	41¼	28½	27	43¼	51¾	29	26	54¼	57½	44½	39	55¾	71	40¾	4	6 0	41¾	3	3 0
7	¾	1	3½	—	27 9	61	61¼	45¾	54	67¾	60¾	48½	47¾	53½	58	45	43¼	59¾	56¾	57	50¾	64½	76½	52¾	16	20 3	—	—	—
8	¾	1	—	¾	23 3	66	74¾	40	52¾	67¼	65¾	44¾	45	57¼	58½	46	44	64¾	60½	71½	48¾	62¼	69	53½	16¾	27 0	55	16¼	25 6
9	¾	1	3½	¾	33 9	70¾	61	46	53¼	62¼	68½	44¾	48¼	57¼	60¾	52¾	43¼	66	59½	73¾	55	58	75½	54	17¼	18 0	56¾	18	20 3
10	⅜	½	3½	¾	25 0	63¼	58¼	43½	45¼	68¼	61¾	35¼	35¾	60	52	47	34	61	55¾	70¾	57¼	50¼	69	47¼	10½	6 6	—	—	—

* The plots included in this average are Diamond Hall; Low Bradley; Newlands Haugh; West Farm, Medomsley, 'B' plots; Springs House, 1–5 A and 6–10 B.

† The plots included in this average are the foregoing and Byers Garth 'A' plots: West Farm, Medomsley, 'A' plots, and Hesleden 1, 2, 8 and 9 B, and 6 A.

Standard Dressing (Plot 9):—

Nitrogen ..	..	35 lbs. per acre (half in nitrate, half in sulphate).
Phosphoric acid	..	50 lbs. ,,
Potash ..	..	35 lbs. ,,

TABLE V.—EIGHTH CROP (OATS) IN A ROTATION

PLOTS ¼-ACRE (EXCEPT 10 AND 10A

Plots.	Manuring for 1898. (Swedes.)							Manuring for 1899. (Barley.)	Manuring for 1900. (Hay.)				Manuring for 1901. (Oats.)		
	Dung.	Bone Meal.	Dis. Bones.	Super.	Slag.	Fish Meal.	Kainit.	Fish Meal.	Dung.	Super.	Fish Meal.	Kainit.	Super.	Fish Meal.	Kainit.
	Tons.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Tons.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
1	12	...	...	...	...	...	...	...	...	...	...	...	..	...	...
2	12	...	...	5¾	...	2	...	...	...	...	...	...	...	...	...
3	12	...	...	11½	...	4	...	...	...	...	...	...	...	...	...
4	12	...	...	2⅞	...	...	...	2	...	2⅞	...	...	...	...	...
5	6	...	...	5¾	...	2	...	...	6	...	...	...	...	...	...
6	6	...	...	5¾	...	2	...	...	...	...	...	...	...	...	...
7	9	...	...	5¾	...	2	...	...	...	...	...	...	...	...	...
8	15	...	...	5¾	...	2	...	...	...	...	...	...	...	...	...
9	12	...	...	2⅝	..	1	...	...	...	...	...	...	...	...	...
10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10A	12	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11	12	3½	...	...	...	...	...	...	...	...	...	...	...	...	...
12	12	...	5½	...	...	...	...	...	...	...	...	...	...	...	...
13	12	...	...	5¾	...	2	...	...	...	...	...	...	...	...	...
14	12	...	...	...	4½	2	...	...	...	...	...	...	...	...	...
15	12	...	...	5¾	...	2	4	...	...	...	...	...	...	...	...
16	12	...	...	2⅝	...	1	...	½	...	1⅝	...	2	1⅜	½	2
17	12	...	...	5¾	...	2	...	...	...	...	...	4	...	...	...
18	12	...	...	2⅝	...	...	...	...	...	2⅝	1	1	...	1	...
19	*12	...	...	2⅝	...	...	...	...	...	2⅝	1	1	...	...	...
20	†24	...	...	2⅝	...	...	...	..	...	2⅞	1	1	...	...	...

* 12 tons horse dung, well rotted, at Whitefield; 15 tons, fresher, at Peepy.
† 24 tons Newcastle Corporation manure at both stations.

NOTE.—Plots 11, 12, 13, and 14 received, for 1898, 95 lbs. phosphoric acid and 17½ lbs. of nitrogen per acre in the form of the artificial manures indicated.
For 1900 all plots received at the rate of ½ cwt. per acre of nitrate of soda.

XPERIMENT AT PEEPY AND WHITEFIELD.

-ACRE). FIGURES PER ACRE.

Yield of Oats, 1901.					
Peepy.		Whitefield.		Average.	
Grain.	Straw.	Grain.	Straw.	Grain.	Straw.
Bush. of 42 lbs.	Cwt.	Bush. of 42 lbs.	Cwt.	Bush. of 42 lbs.	Cwt.
51¼	30½	28¾	18¼	40	24½
50½	29¾	36½	21	43½	25½
56¾	31¾	45¾	20	51½	26
57¼	31¼	47½	21	52½	26
62	33½	58¼	21	60	27¼
49	26¼	43	20½	46	23½
54	29¾	50	20¾	52	25¼
60¾	34	55¾	22¾	58¼	28½
53½	32	53¾	21½	53½	26¾
37¼	23¾	36¼	18	36¾	21
42½	30¼	53½	21½	48	26
45½	28¾	44¾	18¼	45	23½
49	29½	51	19¼	50	24½
49¼	29½	53½	21¼	51½	25½
49½	29½	54¾	17¼	52	23½
49¾	29¾	55¼	22½	52½	26
50¾	32¾	54½	22¼	52½	27½
42	30¼	52½	21	47¼	25½
48¼	29¾	55	19	51¾	24½
42	28¼	50	24¾	46	26½
37¼	27	52	19½	44½	23¼

TABLE VI.—ROTATION EXPERIMENT AT PEEPY AND WHITEFIELD.

VALUES OF THE FOUR CROPS OF THE SECOND ROTATION. FIGURES PER ACRE.

Plots.	Swedes, 1898, 8/- per ton.		Barley, 1899; corn, 25/- per qr. of 448 lbs.; straw, 25/- per ton.				Hay, 1900, £3 per ton.				Oats, 1901; corn, 20/- per qr. of 336 lbs.; straw, 35/- per ton.				Gross Value of Four Crops.		Plots.
	Peepy.	White-field.	Peepy.		Whitefield.		Peepy.		Whitefield.		Peepy.		Whitefield.		Peepy.	Whitefield.	
			Corn.	Straw.	Corn.	Straw.	First Cut.	Second Cut.	First Cut.	Second Cut.	Corn.	Straw.	Corn.	Straw.			
	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	
1	6 5	8 9	6 13	1 17	6 5	1 6	6 10	2 5	5 5	0 5	6 8	2 13	3 12	1 12	32 11	26 14	1
2	6 13	8 15	6 18	1 17	6 12	1 9	6 18	2 8	5 10	0 13	6 6	2 12	4 11	1 17	33 13	29 8	2
3	6 18	9 5	7 6	1 18	7 12	1 11	7 1	2 12	5 15	0 15	7 2	2 16	5 14	1 15	35 13	32 7	3
4	6 19	9 2	7 19	2 0	8 0	1 14	6 19	2 11	6 9	0 14	7 3	2 15	5 18	1 17	36 6	33 15	4
5	6 11	8 19	6 11	1 14	6 15	1 8	6 6	2 19	7 8	1 9	7 15	2 19	7 6	1 17	34 17	35 3	5
6	6 10	9 5	6 17	1 11	7 1	1 11	6 11	1 19	5 10	0 10	6 2	2 6	5 8	1 16	31 16	31 0	6
7	6 12	9 3	7 2	1 16	7 8	1 14	6 2	2 4	6 4	0 10	6 15	2 12	6 5	1 16	33 3	33 1	7
8	6 17	9 13	7 10	1 19	7 15	1 18	7 5	2 15	6 14	0 19	7 12	2 19	6 19	2 0	36 19	35 18	8
9	6 16	9 13	7 4	1 13	8 2	1 16	5 6	2 7	6 2	0 13	6 14	2 16	6 15	1 18	32 17	34 19	9
10	4 2	5 0	4 12	1 5	4 14	1 4	5 18	1 11	4 7	0 4	4 13	2 2	4 10	1 11	24 5	21 12	10
10A	6 18	9 6	6 9	1 11	7 3	1 12	6 14	2 2	6 13	0 17	5 6	2 13	6 14	1 18	31 13	34 2	10A
11	6 19	8 15	7 8	1 15	7 6	1 11	6 11	2 0	6 4	0 15	5 14	2 10	5 12	1 12	32 17	31 15	11
12	6 18	8 17	7 6	1 15	7 1	1 9	5 17	2 2	6 12	0 16	6 2	2 12	6 7	1 14	32 12	32 16	12
13	6 17	9 2	7 11	1 11	7 2	1 10	6 7	1 19	6 13	1 2	6 3	2 12	6 14	1 17	33 2	34 2	13
14	6 14	8 19	7 19	1 18	7 4	1 10	6 7	2 5	6 12	0 11	6 4	2 12	6 17	1 10	34 1	33 4	14
15	7 1	9 3	7 13	1 17	7 8	1 10	6 11	2 4	6 10	0 12	6 4	2 12	6 18	1 19	34 3	34 1	15
16	6 8	8 18	7 11	1 15	8 2	1 10	6 14	2 2	6 19	0 16	6 7	2 17	6 16	1 19	33 14	35 2	16
17	6 15	8 9	7 15	1 15	7 15	1 11	6 13	1 17	6 10	0 13	5 5	2 13	6 11	1 17	32 12	33 8	17
18	6 7	8 16	7 12	1 15	7 8	1 10	6 13	1 14	6 13	0 11	6 1	2 12	6 18	1 13	32 15	33 11	18
19	6 7	9 7	7 13	1 16	7 19	1 12	6 14	1 14	6 16	0 7	5 5	2 9	6 5	2 3	32 1	34 10	19
20	6 0	8 10	7 7	1 19	7 8	1 10	6 5	1 6	5 18	0 8	4 13	2 7	6 10	1 14	29 19	31 18	20

NOTE.—Values are given to the nearest shilling. The figures in the last two columns have been got by adding the actual values of the four crops, and may differ by an amount not exceeding 2s. from the sum of the figures in the other columns.

BLE VII.—ROTATION EXPERIMENT AT PEEPY AND WHITEFIELD.

AVERAGE VALUE PER ACRE OF THE FOUR CROPS OF THE SECOND ROTATION.

Swedes 1898.	Barley, 1899.			Hay, 1900.			Oats, 1901.			Gross value of Four Crops.	Plots.
	Corn.	Straw.	Corn and Straw.	1st cut.	2nd cut.	1st cut. and 2nd cut.	Corn.	Straw.	Corn and Straw.		
£ s.	£ s.	£ s.	£ .	£ s.	s.	£ s.	£ s.	£ s.	s.	£ s.	
7 7	6 9	1 11	8 0	5 17	1 5	7 2	5 0	2 3	7 3	29 12	1
7 14	6 15	1 13	8 8	6 4	1 11	7 15	5 9	2 4	7 13	31 11	2
8 2	7 9	1 15	9 4	6 8	1 13	8 1	6 8	2 5	8 13	34 0	3
8 0	7 19	1 17	9 16	6 14	1 13	8 7	6 11	2 6	8 17	35 1	4
7 15	6 13	1 11	8 4	6 18	2 4	9 2	7 10	2 8	9 18	35 0	5
7 18	6 19	1 11	8 10	6 1	1 4	7 5	5 15	2 1	7 16	31 8	6
7 17	7 5	1 15	9 0	6 3	1 7	7 10	6 10	2 4	8 14	33 2	7
8 5	7 12	1 18	9 10	7 0	1 17	8 17	7 6	2 10	9 16	36 9	8
8 5	7 13	1 14	9 7	5 14	1 10	7 4	6 14	2 7	9 1	33 18	9
4 11	4 13	1 5	5 18	5 3	0 18	6 1	4 12	1 17	6 9	22 19	10
8 2	6 16	1 11	8 7	6 13	1 10	8 3	6 0	2 5	8 5	32 18	10A
7 17	7 7	1 13	9 0	6 8	1 7	7 15	5 13	2 1	7 14	32 6	11
7 17	7 4	1 12	8 16	6 4	1 9	7 13	6 5	2 3	8 8	32 14	12
8 0	7 6	1 10	8 16	6 12	1 11	8 3	6 8	2 4	8 12	33 12	13
7 17	7 11	1 14	9 5	6 11	1 8	7 19	6 10	2 1	8 11	33 13	14
8 2	7 10	1 14	9 4	6 10	1 8	7 18	6 11	2 6	8 17	34 2	15
7 13	7 17	1 13	9 10	6 17	1 9	8 6	6 11	2 8	8 19	34 8	16
7 12	7 15	1 13	9 8	6 12	1 5	7 17	5 18	2 5	8 3	33 0	17
7 12	7 10	1 13	9 3	6 13	1 3	7 16	6 9	2 3	8 12	33 3	18
7 18	7 16	1 14	9 10	6 15	1 1	7 16	5 15	2 6	8 1	33 5	19
7 5	7 7	1 14	9 1	6 2	0 17	6 19	5 12	2 1	7 13	30 19	20

NOTE.—Values are given to the nearest shilling. The figures in the last column have been got by adding the actual values of the four crops, and may differ by an amount not exceeding 2s. from the sum of the figures in the other columns.

For the rates at which the crops have been valued see Table VI.

TABLE VIII.—ROSE BANK ROTATION EXPERIMENT. SECOND COURSE. FIRST YEAR.

PLOTS ¼-ACRE. FIGURES PER ACRE.

Plots.	Manuring per acre for Roots.						Manuring for subsequent Crops, Cereal, Hay, Hay, Cereal.	Yield of Roots, 1901.	
	Dung.	Sulph. Amm.	Super.	Dis. Bones.	Bone Meal.	Mur. Pot.			
	Tons.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.		Tons.	Cwt.
1	...	1	1½	1½	1	...	Nothing	19	7
2	...	1	1½	1½	1	⅞	Do.	21	16
3	..	¾	1	1	1¼	⅝	One half of dressing applied to roots for each hay crop	17	0
4	9	...	...	...	...	...	Nothing	18	6
5	9	1	1½	1½	1	...	Do.	20	9
6	9	..	...	...	...	...	One fourth of dressing applied to roots on Plot 5 to each crop	17	11
7	9	...	...	...	...	½	Same as Plot 6, with additional ½ cwt. muriate of potash to each hay crop	17	5
8*	9	⅜	...	...	1	...	1¾ cwt. mixed superphosphate, dissolved bones, and sulphate of ammonia to first hay crop and final cereal crop	18	15
9*	9	1⅛	3	3	...	...	Nothing	21	15
10*	9	½	1½	1½	...	...	Same as Plot 8	20	0
11	...	...	...	...	...	...	Nothing	1	5
12	15	...	...	...	...	...	Do.	18	16
13	15	1	1½	1½	1	...	Do.	20	18
14	15	...	...	...	...	...	Same as Plot 6	19	9
15	15	⅜	...	...	1	...	Same as Plot 8	19	4
16	15	1⅛	3	3	...	...	Nothing	20	9
17	15	½	1½	1½	...	...	Same as Plot 8	17	19
18	15	...	...	...	...	½	Same as Plot 7	16	2
19	9	..	...	...	...	...	Nothing	15	7
20	9	...	...	...	...	...	¾ cwt. nitrate of soda to each crop	17	11
21	9	...	...	...	...	...	Nothing	17	6
22	9	1	1½	1½	1	...	Half of root crop fed off by sheep getting 6 cwt. seeds hay per acre	18	12
23	9	1	1½	1½	1	...	Half of root crop fed off by sheep getting 6 cwt. seeds hay per acre and 5 cwt. linseed cake	18	7
24	9	1	1½	1½	1	...	151 lbs. fish meal, 50 lbs. sulphate of ammonia, 12½ lbs. muriate of potash to first corn crop only †	19	14

NOTES.—The standard application (as given to Plot 1) consisted of 100 lbs. phosphoric acid (50 lbs. from bone meal, 25 lbs. from the soluble phosphate in superphosphate, and 25 lbs. from the total phosphates in dissolved bones), and 35 lbs. nitrogen in sulphate of ammonia, bone meal and dissolved bones. In the case of Plot 2 and the other plots receiving potash, 50 lbs. in the form of muriate have been applied.

* In Plots 8 and 15, where half of the standard dressing for Plot 1 is applied to the root crop and the remainder to hay and cereals, the insoluble bone meal goes on the roots, the other phosphatic manures being retained for top-dressing hay and cereals. In Plots 9, 10, 16 and 17 all the phosphates are supplied in superphosphate and dissolved bones, either to the roots or distributed as shown in the table.

† The sheep on Plot 23 consumed 5 cwt. cake per acre, and after allowing for the amount retained by the animal, the dressing of fish meal, etc., supply to plot 24 the amount by which the cake residues may be assumed to have enriched Plot 23.

TABLE IX.—KIMBLESWORTH ROTATION EXPERIMENT.
SECOND COURSE, FIRST YEAR.
PLOTS ⅛-ACRE. FIGURES PER ACRE.

Plots.	Manuring per Acre for Roots.					Manuring for subsequent Crops, Cereal Hay, Hay Cereal.	Yield of Roots, 1901.	
	Dung.	Sulph. Amm.	Super.	Slag.	Muriate of Potash.			
	Tons.	Cwt.	Cwt.	Cwt.	Cwt.		Tons.	cwt.
5	18	...	...	...	...		19	14
6	18	...	...	...	...		19	17¼
7	18	1⅛	6	...	...		22	4
8	18	...	...	...	...	Artificials given to Roots on Plot 7 spread over the four subsequent crops	20	9¼
9	12	9/16	3	...	...		19	15½
10	...	...	...	...	...	Nothing	1	8
11	12	9/16	3	...	...	Same as Plot 8 for first Hay and last Cereal Crop	20	9¼
12	12	...	...	...	...	Same as Plot 8	18	10
13	12	1⅛	6	...	...		19	17½
14	12	1⅛	...	5	...		20	9¾
15	12	...	...	...	...	Same as Plot 8, but Slag instead of Superphosphate	19	1¾
16	12	...	...	...	...		19	13¼
17	12	...	...	...	...		20	5
18	12	...	...	...	...		17	2¼
*19	...	1⅛	6	...	...	Same as Plot 8, and in addition ½ cwt. Muriate to each crop	18	1¾
†20	...	1⅛	6	...	1	Same as 19...	20	4½
21	...	1⅛	6	...	...		17	13¾
22	...	1⅛	6	...	...		19	0¼

Standard Dressing (Plot 20):—

Nitrogen	25 lbs. per Acre	to Roots.
Phosphoric Acid	100 lbs. ,,	
Potash	50 lbs. ,,	

* All Plots will get about ¾ cwt. Nitrate of Soda (12·5 lbs. Nitrogen) for the first Hay Crop and last Cereal Crop.

† Plot 20 was known as 19, and Plot 19 as 20 in last rotation.

TABLE X.—SEVENTH YEAR OF CUMBERLAND

PLOTS $\frac{1}{20}$-ACRE.

Plots.	Manuring per Acre for Crops, 1896, 1897, 1898, 1899, 1900, and 1901, and almost the same as for 1895.						Average Cost of Manures in Seven Years.		Produce of Hay per Acre, 1901.			
	Dung.	Sulph. of Amm.	Nitr. of Soda.	Super.	Slag.	Kainit.			Blencow.	Castle Carrock.	Eskdale.	Glasson.
							s.	d.	Cwt.	Cwt.	Cwt.	Cwt.
1	...	...	...	...	...	...	...		17	6¼	12	8¼
2	...	...	1	...	...	...	8	5	22½	7	17¼	8
3	...	...	...	2½	...	...	7	3	27½	8½	30	11
4	...	...	...	...	1⅞	...	4	5	23¼	8¾	26	9½
5	...	...	...	...	...	2½	6	1	22½	7	23¼	10
6	...	...	1	2½	...	...	15	8	29¼	8½	24¾	14
7	...	...	1	...	...	2½	14	7	25¾	12¼	29	12¼
8	...	...	...	2½	...	2½	13	5	21½	16¾	42¼	15¾
9	...	...	1	2½	...	2½	21	9	26¼	19¼	40	13½
10	...	...	1	...	1⅞	2½	18	11	22	16¼	45¾	16¼
11	...	...	1	1¾	$\frac{15}{16}$	2½	20	5	24½	18¼	42¼	20¼
12	...	¾	...	...	1⅞	2½	18	6	21¼	8¼	32¼	17¾
13	10	⅜	...	...	$\frac{15}{16}$	1¾	28	7	15½	17½	19	16
14	...	⅜	...	...	$\frac{15}{16}$	1¾	9	4	21½	11	23	10¾
15	10	⅜	...	...	$\frac{15}{16}$	1¾	34	1	29½	19¾	41	10¾
16	10	...	...	...	...	...	28	7	26¾	14½	41	23½

The Mixtures for Plots 9—12 supply 17·5 lbs. Nitrogen, 35 lbs. Phos. Acid, and 35 lbs. Potash per Acre.

Plot 13 gets Dung and Artificials separately in alternate years, namely, Dung in 1896, 1898, 1900, etc.; Artificials in 1895, 1897. 1899, etc.

Plot 14 got ¾ cwt. Sulphate of Ammonia in 1900.

HAY EXPERIMENTS (SET I.)

FIGURES PER ACRE.

Average Increase. Eskdale and Castle Carrock, 1901.	Average Hay Crop.				Average Increase in Seven Years on Eskdale and Castle Carrock.	Average Profit in Seven Years on Eskdale and Castle Carrock.	
	Seven Years, 1895-1901.			Five Years, 1895, '96, '98, '99, 1901.			
	Blencow.	Castle Carrock.	Eskdale.	Glasson.			
Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	s.	d.
...	21¼	20	18¼	10¾	...	...	
3	26¼	25½	23	12¼	5½	5	4
10¼	30½	22¼	24	15½	4	2	9
8¼	28¼	21½	21	14¾	2¼	1	2
6	27¾	24	21¼	16½	3½	2	8
7½	30¾	23½	28¼	21½	6¾	1	2
11½	28¼	28	30	16½	10	10	5
20½	23¾	26	33	19	10½	12	10
20½	26¾	30¾	35½	21¾	14	13	3
22	27	29¼	35	22½	13	13	7
21¼	27	31¼	34	23½	13½	13	4
11¼	25½	27¾	28½	22¾	9	4	0
9¼	24	32½	29	19¾	11¾	0	9
8	23¼	26½	28½	16¾	8½	11	11
21¼	28½	34½	38	18½	17¼	4	0
18¾	26½	28¼	37	20¾	13½	5	2

Plot 15 gets both Dung and Artificials in alternate years, namely, 1895, 1897, 1899, etc., and nothing in the intervening years.

Plot 16 gets Dung alone in alternate years, namely, 1895, 1897, 1899, etc., and nothing in ntervening years. (Applied at Glasson in 1900 by mistake.)

TABLE XI.—SEVENTH YEAR OF CUMBERLANI

PLOTS $\frac{1}{20}$-ACRE

Plots.	Manuring per Acre. Manures applied in 1895, 1897, 1898, and 1900 only.								Cost of Manures.		Produce of Hay, 1901.			
	Nitrate Soda.	per.	Slag.	is. Bones.	Bone Meal.	Fish Meal.	Kainit.	Lime.			Brampton.	Gosforth.	Kirkbampton.	Wigton.
									s.	d.	Cwt.		Cwt.	Cwt.
1	...	...	...	...	...	...	...	...	...	...	16	Not weighed this year.	27	23¾
*2	1	3⅝	...	...	...	...	3⅝	...	14	11	18¼		29½	22¼
3	1	1¾	...	...	...	...	3⅝	...	12	2	15¼		32¼	21¼
4	1	5⅜	...	...	...	...	3⅝	...	17	8	14		25¼	23½
5	1	3⅝	...	...	...	...	1¾	...	12	8	15¼		26	5¾
6	1	3⅝	...	...	...	...	5⅝	...	17	3	18¼		26½	22¼
7	½	3⅝	...	...	...	...	3⅝	...	12	6	25		23¼	22¼
8	1½	3⅝	...	...	...	...	3⅝	...	17	6	29¼		27¾	26½
9	½	...	2½	...	...	...	3⅝	...	10	7	30		28¾	27¼
10	½	...	3¾	...	...	...	3⅝	...	12	4	29¼		29¾	24¾
11	...	...	...	3	...	..	3⅝	...	13	3	21¾		28¼	22¼
12	...	...	...	...	2	...	3⅝	...	11	2	25½		32¾	29¼
13	...	...	2¼	...	...	1	3⅝	...	10	11	30		27¼	22¾
†14	⅕	¾	1	⅗	⅖	⅕	3⅝	...	11	8	27½		30¼	20¼
15	$\frac{1}{10}$	⅜	½	$\frac{3}{10}$	⅕	$\frac{1}{10}$	1¾	...	5	10	29¼		26½	21
16	$\frac{1}{10}$	⅜	½	$\frac{3}{10}$	⅕	$\frac{1}{10}$	1¾	5‡	8	5	26		28½	19¼

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* This Mixture supplies 17·5 lbs. Nitrogen, 50 lbs. Phosphoric Acid (insoluble Phosphates in Super. not reckoned), and 50 lbs. Potash per acre.

† One-fifth of the Collective Dressings of Plots 7, 9, 11, 12 and 13.

Contained 500 lbs. Caustic Lime.

HAY EXPERIMENTS (SET II.)

FIGURES PER ACRE.

Average Increase Kirkbampton and Brampton, 1901.	Average Crop in Seven Years, 1895-1901.				Average Increase, Kirkbampton and Brampton.					Plots.
	Brampton.	Gosforth, 1895-1900.	Kirkbampton.	Wigton.	1895, 1897, 1898, and 1900. When Plots manured.	1896, 1899, and 1901. When Plots unmanured.	Seven Years, 1895-1901.	Profit on Increase. Hay at 50s. per ton.		
	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	s.	d.	
...	21¼	25½	28¼	26¾	...	...	...	...		1
2½	27½	33	39¼	31	13½	2	8¾	7	0	2
2¼	25½	29	40	30	12½	2	8	7	10	3
2	27	33½	36¾	35½	12¼	...	7¼	1	5	4
1	26	30½	34	35	10	1¼*	5¼	0	5	5
¾	28¾	31¼	37¼	36½	13¼	1¾	8¼	8	0	6
2½	30½	30¼	35	31	11¼	3¼	8	2	9	7
7	31	32¼	38¼	35	13½	4¾	9¾	11	10	8
7¾	29¾	30½	36	36¼	10	5¾	8¼	3	1	9
8	32½	31¼	36	36½	12¼	5¾	9½	13	2	10
3½	29¾	33	34¼	34	9¾	4	7¼	5	9	11
7½	28	33	35¾	36	9	4¾	7¼	4	10	12
7	30¾	32¼	35	33	10¾	4¾	8¼	9	5	13
7½	32¾	35¼	40¼	32½	15¾	6⅓	11¾	18	5	14
6½	31	27	32¾	32	9¼	4	7¼	12	3	15
5¾	25¾	25¾	33½	27¾	6¾	2¼	5	4	1	16

* Decrease.

TABLE XII.—SIXTH YEAR OF EXPERIMENT ON OLD LAND HAY AT SHIELD ASH, WEARDALE, CO. DURHAM.

PLOTS $\frac{1}{20}$-ACRE. FIGURES PER ACRE.

Plots.	Manures Applied per Acre for Crops of 1896, 1897, 1898, 1899, 1900, and 1901.											Yield per Acre of Crop, 1901.	Average Yield in Six Years.	Average Increase in Six Years.	Average Profit in Six Years.		Increase per Acre.					
	Dung.	Sulphate of Ammonia.	Nitrate of Soda.	Superphosphate.	Slag.	Dissolved Bones.	Bone Meal.	Fish Meal.	Kainit.	Average Cost of Manures.							1896	1897	1898	1899	1900	1901
	Tons.	C.	C.	C.	C.	C.	C.	C.	C.	s.	d.	Cwt.	Cwt	Cwt.	s.	d.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
1	..	...	...	...	...	...	...	...	...	...		17¾	22¼	...	...		...	...	...	...	..	...
2	...	...	½	3¼	...	...	...	...	...	12	3	27½	30½	8¼	8	4	1	4	10	12	10¾	9¾
3	...	...	½	...	...	...	...	...	1¾	8	3	28¼	29¼	7	9	3	3	3½	8¾	10¾	9¼	10½
4	...	...	...	3¼	...	...	...	...	1¾	12	10	27¾	31¼	9	9	8	2	5½	8¾	12¾	16	10
5	...	...	½	3¼	...	...	...	...	1¾	15	10	24	34½	12¼	14	9	8¼	7¾	18¾	18¼	14	6¼
6	...	⅜	...	3¼	...	...	...	...	1¾	16	5	25¾	34¼	12	13	7	4	7	19	17¼	16½	8
7	...	⅜	...	...	2⅜	...	...	...	1¾	13	4	24¾	34	11¾	16	0	2½	7	17¼	19¾	17½	7
8	...	...	...	...	...	2⅝	...	...	1¾	17	2	22¼	32½	10¼	8	5	¾	4¾	17½	17¼	16½	4½
9	...	...	...	...	2	...	...	⅞	1¾	13	0	29¾	39¾	17½	30	9	10	12¼	19½	26	25¼	12
10	...	...	...	...	...	...	1⅞	...	1¾	13	10	30¾	36¾	14½	32	5	7	8½	16	22¼	20¾	13
11	...	⅛	⅛	1⅝	⅝	⅝	...	...	1¾	16	0	31	39¾	17½	27	9	10¾	11	20½	25¾	24½	13¼
12	...	...	...	...	4⅝	...	...	...	...	10	5	26	35¼	13	22	1	9½	10	15	20¼	15	8¼
13	10	...	...	...	4⅝	...	...	...	...	30	0	33½	40½	18¼	15	7	7½	13¼	24	25¾	23½	15¾
14	5	...	...	...	...	...	...	...	...	25	0	34	38¼	16	15	0	7¾	10¼	20	23¼	19	16¼
15	10	...	...	...	...	...	...	...	...	25	0	31¾	35½	13¼	8	1	10	9½	18½	14	13¾	14
16	10	⅛	...	1⅝	⅝	⅝	...	...	1¾	33	0	34¾	43	20¾	18	10	12¼	14½	30	25	26¾	17

NOTES.—Plot 8 was taken as the Standard Plot in 1895; the 2½ cwt. Dissolved Bones then used, supplied 8·06 lbs. Nitrogen, and 36·4 lbs. Phosphoric Acid, and the 2 cwt. Kainit, 28·8 lbs. Potash. The manures applied to the other plots were based upon these proportions. In 1900 the Dissolved Bones used, supplied the same quantity of Nitrogen, but 45·75 lbs. Phosphoric Acid. The quantity of Kainit was altered so as to give 25 lbs. Potash per acre. In the case of Superphosphate the insoluble phosphates have been neglected.

Plot 11 gets one-fourth of the collective Dressings of Plots 5, 6, 7, and 8.

Plot 13 got Dung for 1896, Slag for 1897, and Dung for 1898, and will continue to receive these subtances in alternate years.

Plot 14 gets 5 tons of Dung annually. Plot 15 gets 10 tons of Dung in alternate years, beginning with the crop of 1896.

Plot 16 got Artificials for crop 1896, Dung for 1897, Artificials for 1898, and so on in alternate years.

The Hay is valued at 50s. per ton, Dung 5s. per ton.

TABLE XIII.—NINTH CROP OF EXPERIMENT ON OLD LAND HAY AT BROOMHAUGH, NORTHUMBERLAND. (B. PLOTS.)

PLOTS $\frac{1}{40}$-ACRE. FIGURES PER ACRE.

Plots.	Manuring.						Average Cost of Manure.			Yield 1901.	Average Yield in 9 Years.	Average Increase in 9 Years over the Unmanured Plot.	Average Gain or Loss (—) in 9 Years.	
	Dung.	Sulphate of Ammonia.	Nitrate of Soda.	Superphosphate.	Slag.	Kainit.								
	Tons.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	£	s.	d.	Cwt.	Cwt.	Cwt.	s.	d.
1	...	...	...	...	...	...		...		6	10¼	...	...	
2	...	...	1	...	...	...	0	7	4	7	14	3¾	2	0
3	...	...	...	...	3½	...	0	7	1	7¼	13¼	3	0	5
4	...	...	...	...	...	2½	0	6	4	7¾	10	*¼	-6	11
5	...	...	1	...	3½	...	0	14	5	9	16¾	6½	1	10
6	...	...	1	...	...	2½	0	13	8	6¼	13½	3¼	-5	7
7	...	...	...	...	3½	2½	0	13	7	8½	21¼	11	13	11
8	...	...	1	...	3½	2½	1	0	11	9¾	25	14¾	15	11
9	...	¾	...	...	3½	2½	1	0	5	11	18¼	8	0	5
10	...	...	1	2¼	...	2½	0	14	11	11½	19¼	9	7	7
11	10	...	...	...	...	...	1	7	9	14½	25½	15¼	10	4

* Decrease.

NOTES.—In 1893 and 1894 the Artificial Dressings were 4½ cwt. Slag, 3 cwt. Superphosphate, and 5 cwt. Kainit. No manure was applied in 1895. The above quantities of Artificials have been applied annually since 1896.

Plot 11 got 10 tons Dung per acre in 1893, 1894, 1896, 1898, and 1900.

Standard dressing (Plot 8) :—

Nitrogen	17·5 lbs.	per acre.
Phosphoric Acid ..	70 lbs.	„
Potash	35 lbs.	„

Plot 10 receives 35 lbs. Phosphoric Acid in Superphosphate.

TABLE XIV.—EIGHTH CROP OF EXPERIMENT ON OLD LAND HAY AT SEAHAM, CO. DURHAM.

PLOTS $\frac{1}{20}$-ACRE. FIGURES PER ACRE.

Plots.	Manures applied per Acre to Crops, 1894, 1896, 1897, 1898, 1899, 1900, and 1901. Nothing in 1895.									Average Cost of Manures.		Yield per Acre of Crop 1901.	Average Yield in 8 years.	Average Increase in 8 years.	Average Gain or Loss (–) in 8 years.	
	Dung.	Sul. Am.	Nitrate of Soda.	Super.	Slag.	Dis. Bones.	Fish Meal.	Kainit.	Lime Dust.							
	Tons.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	s.	d	Cwt.	Cwt.	Cwt.	s.	d.
1	…	…	…	…	…	…	…	…	…	…		21½	24½	…	…	
2	…	…	1	…	…	…	…	…	…	7	7	29	29¼	4¾	4	3
3	…	…	…	7¼	…	…	…	…	…	14	3	23	24¾	¼	–13	8
4	…	…	…	…	…	…	…	5	…	10	0	16	23½	*1	–12	6
5	…	…	½	3⅝	…	…	…	…	…	10	10	23¼	29½	5	1	8
6	…	…	½	…	2½	…	…	…	…	8	3	25½	27¼	2¾	–1	5
7	…	…	½	…	…	…	…	2½	…	9	0	25½	26¼	1¾	–4	8
8	…	…	½	3⅝	…	…	…	…	3⅛	13	1	27¾	26¾	2¼	–7	6
9	…	…	½	3⅝	…	…	…	2½	…	17	3	26½	27½	3	–9	9
10	…	…	½	…	2½	…	…	2½	…	13	4	28¼	30½	6	1	8
11	…	…	…	3⅝	…	…	…	2½	…	12	3	23¼	27½	3	–4	9
12	…	…	⅜	2⅜	…	…	…	1⅝	…	10	8	23¾	31¼	6¾	6	2
13	…	…	½	1⅞	1¼	…	…	2½	…	14	8	28	35¼	10¾	12	2
14	…	…	…	…	…	2⅞	…	2½	…	17	0	29½	31¾	7¼	1	2
15	…	…	…	3⅛	…	…	1	2⅜	…	16	1	25¾	30¼	5¾	–1	9
16	…	⅜	…	3⅝	…	…	…	2½	…	16	0	28¼	29	4½	–4	9
17	…	lbs. 8·6	¼	2⅛	½	⅝	¼	2½	…	15	0	29¾	32	7½	3	9
18	…	4·3	⅛	1	¼	…	⅛	1¼	…	7	6	29¾	33¾	9¼	15	7
19	10	4·3	⅛	1	¼	…	⅛	1¼	…	30	4	42¾	39¼	14¾	6	6
20	10	…	…	…	…	…	…	…	…	25	0	34½	39½	15	12	6

NOTES.—The Lime Dust for Plot 8 contained 250 lbs. Caustic Lime

* Decrease.

In 1894 Plot 14 got 280 lbs. Dissolved Bones, and 280 lbs. Kainit, supplying 8·9 lbs. Nitrogen, 38 lbs. Phosphoric Acid, and 35 lbs. Potash per Acre; the Dressings given to the other Plots were based upon these amounts. In 1900 the standard was altered to 8·75 lbs. Nitrogen, 50 lbs. Phosphoric Acid, and 35 lbs. Potash per acre for Plot 14, and the same or proportionate quantities for other Plots. In 1894 the "total" Phosphates, but in 1900 the "soluble" Phosphates only, in Super. were reckoned.

Plot 17 gets one-fifth of Dressings of Plots 9, 10, 14, 15, and 16. Plot 19 got both Dung and Artificials in 1894 and 1896, but Artificials only in 1897. For 1898 it got Dung only, and in [illegible] Plot 20 got Dung in 1894, 1896, and

TABLE XV.—COMPOSITION OF DIFFERENT VARIETIES OF SWEDES.

Name of Variety.	Dry Matter (per cent.)			Sugar (per cent.)		
	1900.		1901.	1900.		1901.
	Fresh.	Stored.	Fresh.	Fresh.	Stored.	Fresh.
Sutton's Crimson King	11·48	11·02	10·47	6·05	6·45	4·25
Tait's Best of All	10·83	10·96	9·63	5·95	6·75	4·05
Garton's Model	10·64	10·26	9·46	6·00	6·15	3·75
Drummond's Stirling Castle	11·37	11·54	10·58	6·70	6·80	4·25
Kent & Brydon's XL All	10·47	10·13	9·92	6·30	6·05	4·40
Do. Monarch	11·10	10·61	10·16	5·85	6·30	3·55
Fell's Bronze Top	12·38	12·81	10·41	7·00	7·80	4·45
Webb's Arctic	11·77	11·87	10·87	6·70	7·30	4·65
Drummond's Extra Improved	11·34	12·37	10·13	6·25	7·55	3·60
Carter's Kangaroo	11·73	11·67	10·38	6·00	7·35	3·75
Do. Elephant	11·98	11·27	10·66	6·05	7·05	3·90
Do. Imperial	12·09	11·58	...	6·25	7·05	...
Halewood Bronze Top	11·83	12·35	...	6·85	7·80	...
Fell's Wentworth Purple Top	...		10·85	...	...	4·35
Drummond's Bronze Top	...	...	9·31	...	...	3·75
Webb's New Buffalo	...	...	10·64	...	...	4·50
Carter's Prize Winner	...	...	11·03	...	...	3·95
Kent & Brydon's Darlington Swede	...	...	10·18	...	...	4·05
D.C.S. Monarch Disease Resisting	...	...	10·87	...	...	4·90

TABLE XVI.—VARIATION IN COMPOSITION OF MONARCH SWEDES DUE TO STORING.

Constituents.	Before storing.	Afte storing.
Sugar	5·85	6·30
Amides	·31	·27
Albuminoids	·57	·43
Pectins	3·00	2·22
Woody Fibre	·90	·94
Ash	·46	·46
Total Nitrogen	·140	·110

TABLE XVII.—COMPOSITION OF SWEDES FROM NEW RABY FARM, STAINDROP.

Name of Variety.	Dry Matter (per cent.)	Sugar (per cent.)
Brydon's Perfection	10 99	5·82
Kent and Brydon's Darlington Swede ...	11·02	4·75
Drummond's Extra Improved	10 66	4·87
Tait's Best of All	11·23	5·45
Kent and Brydon's XL All	10·44	4·88

TABLE XVIII.—TOTAL CROP OF SWEDES, AND DRY MATTER IN TOTAL CROP. FIGURES PER ACRE.

Name of Farm.	Manures used.								No Manure.	
	Artificials.		No Nitrogen.		No Phosphates.		No Potash.			
	Tons.	cwt.	Tons.	cwt.	Tons.	cwt.	Tons.	cwt.	Tons.	cwt.
Cleatlam ...	16	0¾	14	10¼	6	6½	14	8½	9	3¼
	1	12½	1	10½	0	14	1	11¼	1	1
Neasham Grange ...	22	2½	22	7¾	11	4	20	5¼	11	17¼
	2	4	2	8½	1	3½	2	2½	1	6
Medomsley, E. ...	17	10	18	15	19	15	18	0	15	10
	2	2	2	7¼	2	8¾	2	4½	1	19
Do., W. ...	22	10	16	0	12	10¾	20	10	16	14¼
	2	9	1	18½	1	7¾	2	9½	2	1
Newlands Haugh ...	28	1½	27	2¾	21	14¼	21	12½	23	1½
	2	15¾	2	12	2	5½	2	5	2	4¾
Sherburn ...	22	8¼	19	10	19	14¾	20	4	14	17½
	2	16	2	3½	2	0	2	2¼	1	17
Birtley ...	20	6	15	18½	14	4	12	19¼	11	15
	2	6	1	16½	1	13	1	9¼	1	7
High Bradley* ...	22	0	20	18½	12	12½	20	10¾	5	0
	1	18	1	18½	1	1¾	1	18	0	10

* Aberdeen Green Top Yellow Turnips.

TABLE XIX.

PERCENTAGE OF DRY MATTER IN POTATOES.

Plot.	Manure.	Blakelaw.	West Cornforth.	Byers Garth, Durham.	Sedgefield.	Riding Mill.
1	18 tons dung	24·18	21·93	21·58	24·66	26·85
2	12 tons dung	24·79	23·16	23·18	25·85	28·25
3	12 tons dung + ½ artificials...	24·56	22·85	23·71	25·22	28·15
4	12 tons dung + artificials ...	23·60	24·04	24·50	23·82	26·31
5	Complete artificial	23·98	23·36	23·14	25·81	28·59
6	Double nitrogen (Sulph. Am.)	22·58	23·85	23·73	25·69	27·26
7	Double nitrogen (Nit. Soda)...	23·64	22·33	23·28	24·80	29·38
8	Double phosphate	24·85	22·56	24·78	27·39	26·91
9	Double potash, as sulphate ...	23·04	23·49	24·27	25·42	30·05
10	Double potash, as muriate ...	22·87	22·35	24·22	26·05	28·10
11	Double potash, as kainit ...	22·79	22·91	24·14	23·51	26·18
12	No manure	24·97	23·16	24·44	27·38	28·20
13	No nitrogen	26·17	23·63	25·30	27·51	28·81
14	No phosphates	25·63	23·45	25·13	25·60	28·77
15	No potash	26·40	23·63	27·78	27·50	29·08

TABLE XX.—COMPOSITION OF SOILS FROM SHIELD ASH.

	Plot I. Samples taken.		Plot XI. Samples taken.	
	1''–8''	8''–12''	1''–9''	9''–12''
Soluble in Hydrochloric Acid.				
Ferric Oxide (Fe_2O_3)	4·99	5·15	5·15	5·08
Alumina (Al_2O_3)	2·00	4·10	3·44	4·47
Lime (CaO)	·54	·43	·81	·72
Potash (K_2O)	·35	·52	·47	·56
Phosphoric Acid (P_2O_5)	·09	·05	·13	·09
Soluble in Citric Acid.				
Potash (K_2O)	·011	·005	·017	·009
Phosphoric Acid (P_2O_5)	·009	·003	·017	·006
Nitrogen (N) Total	·310	·119	·375	·177
Carbonic Acid (CO_2) combined	·04	·05	·21	·09
Organic matter and Water of Combination	10·17	5·26	13·69	6·33
Silica and Silicates insoluble in Hydrochloric Acid	79·31	81·40	77·20	75·67
Stones over 3 mm.	3	3½	2	7
Coarse sand 3 – ·5 mm.	10	14	28	21
Medium „ ·5 – ·25 mm. ...	13	8	17	8
Fine „ ·25 – ·1 mm.	8	11	9	5

TABLE XXI.—COMPOSITION OF SOILS FROM ROSE BANK AND KIMBLESWORTH.

355. Kimblesworth, plot 10, 19th January, 1901.
356. ,, sub-soil, ,,
497. Rose Bank, Cumberland, plot 1, 6th April, 1901.
498. ,, ,, sub-soil, ,,
499. ,, ,, plot 11, ,,
500. ,, ,, sub-soil, ,,
501. ,, ,, plot 24, ,,
502. ,, ,, sub-soil, ,,

	355	356	497	498	499	500	501	502
Soluble in Hydrochloric acid:								
Ferric oxide and alumina	6·60	8 08	6·68	6·64	5·03	6·10	5·33	7·78
Lime	·33	·28	·27	·23	·28	·20	·25	·25
Potash	·27	·38	·37	·34	·33	·26	·30	·36
Phosphoric acid ...	·07	·04	·05	·02	·05	·03	·05	·03
Soluble in citric acid:								
Ferric oxide and alumina	·539	·320	·213	·285	·377	·388	·236	·382
Lime	·132	·134	·091	·089	·167	·106	·123	·125
Potash	·009	·004	·008	·003	·007	·004	·007	·004
Phosphoric acid ...	·004	·001	·009	·003	·008	·004	·007	·0015
Silica	·126	·083	·103	·068	·066	·148	·100	·127
Total nitrogen ...	·143	·070	·188	·065	·169	·058	·143	·050
Carbonic acid ...	*	*	*	*	·03	*	*	·01
Organic matter and water of combination	5·88	4·24	7·00	3·87	17·73	3·68	5·34	3·58
Insoluble silicates ...	80·71	80·35	75·61	67·26	65·71	69·81	71·71	73·72
Stones	4	7	12	20	14	19	16	14
Grits and coarse sand	5	5	5	7	6	6	7	11
Medium sand ...	15	12	12	9	9	10	13	12
Fine sand	10	9	6	5	6	6	5	6
Silt	37	42	42	36	46	38	41	37

* Under ·01 per cent

	Sampled, February, 1901.	Sampled, June, 1901.						
		Cattle under cover, eating Roots, etc.		Sheep under cover.	Cattle Dung made in house.			
		56 lbs. per head daily.	28 lbs. per head daily.		Exposed in heap.	Stored on ground, covered with clay.	Stored in cement pits.	
Sample No.	409	510	511	512	513	514	515	516
Water	82·19	75·12	74·80	70·04	80·15	75·34	82·15	78·55
Organic matter	13·58	20·10	19·94	22·75	12·47	17·10	13·22	16·65
Mineral matter	4·23	4·78	5·26	7·21	7·38	7 56	4·63	4·80
Total	100·00	100·00	100·00	100·00	100 00	100·00	100 00	100·00
Nitrogen as ammonia ...	·146	·145	·206	·247	·035	·020	·115	·033
„ amides	·027	·074	·041	·036	·043	·082	·048	·022
„ albuminoids ...	·320	·595	·545	·554	·525	·459	·315	·113
Total Nitrogen	·493	·814	·792	·837	·603	·561	·508	·468
Total Phosphoric acid ...	·184	·290	·221	·417	·352	·277	·297	·324
Total potash	·460	·710	·627	·835	·651	·475	·340	·472
Lime	·373	·381	·358	·431	·570	·553	·430	·481
Insoluble silicates	2·41	2·47	3·11	4·15	4·62	5·04	2·81	2·69
Mineral matter, soluble in acids	1·82	1·31	2·15	3·06	2·76	2·52	1·82	2·11

Samples Nos. 514 and 516 represent the dung made by animals consuming the produce of Miniature Farms I. and VI., the daily ration would be about 56 lbs. roots, 5 lbs. grain, 7 lbs. hay and a few pounds of straw.

Samples 409 and 515 represent dung made from the produce of Miniature Farm III. where the animals had the same foods as above, with 4 lbs. linseed cake in addition.

Sample 510 was made on a ration of 56 lbs. roots, 7 lbs. hay, 3 lbs linseed cake 2 lbs. mixed meals.

Sample 511 on a ration of 28 lbs. roots, 10 lbs. hay, 3 lbs. cake and 2½ lbs. meal.

Sample 512 was made by sheep receiving 6 lbs. roots, 1¼ lbs. meadow hay and ¾ lb. cake and meal per head daily.

TABLE XXIII.—COMPOSITION OF FEEDING STUFFS FOR COCKLE PARK.

	Decorticated Cotton Cakes.		Pea Meal.	Oat Dust.	Linseed Cake.
Reference No. ...	364	694	359	360	363
Date	23/1/01	31/7/01	23/1/01	23/1/01	29/1/01
Moisture	10·09	8·87	14·08	11·50	10·74
Oil	6·31	11·51	1·03	4·50	11·53
Albuminoids ...	43·94	45·08	23·81	9·19	33·62
Carbohydrates, etc. ...	25·45	22·55	52·28	46·20	31·29
Woody fibre ...	6·57	4·79	6·11	22·26	6·80
Ash	7·64	7·20	2·69	6·35	6·02
	100·00	100·00	100·00	100·00	100·00
Nitrogen	7·03	7·21	3·81	1·47	5·38
Sand	·20	·12	·09	3·49	1·04

TABLE XXIV.—COMPOSITION OF LINSEED CAKE, THISTLE BRAND, USED IN ROSE BANK ROTATION EXPERIMENT, 1901.

Constituent.	Reference No. 654.
Moisture	12·54 per cent.
Oil	8·88 ,,
Nitrogen	4·27 ,,
Phosphoric Acid (P_2O_5)	1·75 ,,
Potash (K_2O)	1·43 ,,

e Durham College of Science,

NEWCASTLE-UPON-TYNE.

CIPAL, HENRY PALIN GURNEY, M.A., D.C.L.

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is list comprises the names of Teachers whose classes are attended by Agricultural Students. lete List of the Professors and Lecturers will be found in the College Calendar.

. . THE . .

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NEWCASTLE-UPON-TYNE.

The College provides complete facilities for the study of Agriculture and Allied Subjects. The Courses of Study, which are adapted to meet the requirements of all classes of Students, are :—

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COUNTY COUNCILS OF CUMBERLAND, DURHAM,
AND NORTHUMBERLAND.

AGRICULTURAL DEPARTMENT

OF THE

DURHAM COLLEGE OF SCIENCE, NEWCASTLE-UPON-TYNE.

ELEVENTH ANNUAL REPORT

ON

IELD AND OTHER EXPERIMENTS,

1902,

COMPILED BY

DOUGLAS A. GILCHRIST, B.Sc., F.R.S.E., F.H.A.S.,

Professor of Agriculture and Rural Economy.

Principal Contents.

- Manures for Old Land Hay.
- Seeds Mixtures for Hay and Pasture.
- Manures for Rotation Crops.
- Manures for Swedes, Mangels, and Potatoes.
- Composition and Feeding Value of Swedes and other Roots.
- Experiments at Newton Rigg Farm School.

LONDON AND NEWCASTLE-UPON-TYNE:
ANDREW REID AND COMPANY, LIMITED, PRINTERS AND PUBLISHERS.

1903.

PREFACE.

The experiments described in this report are carried out in the three northern counties—Cumberland, Durham and Northumberland—on land placed at the disposal of the College by landowners and farmers, who have readily given every assistance with the cultivation and harvesting of the crops grown at the different stations. They also include the experiments on crops and stock made at the Cumberland and Westmorland Farm School, Newton Rigg, Penrith. Mr. Lawrence is entirely responsible for those at Newton Rigg, and also co-operates with the College representatives in carrying out the work at the College centres in Cumberland. The report on the experimental and other work of the Northumberland County Demonstration Farm is now published separately by the Technical Education Committee of that county, and will be issued in July. The work at this farm of 400 acres is carried on as before, under the supervision of the department.

The nature and extent of the field experimental work is shown by the following table:—

Nature of experiments.	Number of experiments.	Number of plots.	Area of land. Acres.
A For several years:—			
Manures for old land hay	16	282	16¼
Manures for rough pasture	1	13	¾
Renovating seeds for rough pasture ...	1	3	3
Seeds mixtures for hay and pasture ...	1	8	4
Manures for rotation crops	4	84	20
B For 1902 only:—			
Manures for seeds hay	4	40	4
Manures for swedes	11	154	6
Manures for mangels	7	105	4
Manures for potatoes	7	84	3
Varieties of swedes	12	45	2½
Total	64	818	63½

The experiments for one season only were under the superintendence of Mr. R. B. Greig, and arranged chiefly in the centres where lectures to farmers were delivered by him.* These experiments prove of great service in indicating the general needs of the soils of these districts, and are preparatory to the initiation of experiments of a more permanent character.

The artificial manures for the experiments are all analysed and weighed out at the College, and sent free of cost to the different stations. Members of the agricultural staff measure off the plots, attend when necessary to see the manures applied, inspect the growing crops, conduct parties over the plots when desired, and in almost all cases see the produce weighed.

A standard dressing is usually fixed for each experiment with artificial manures. This supplies a certain number of pounds of nitrogen, phosphoric acid, and potash, contained in various different manures.

The following table gives some particulars of the composition and the prices of the various manures; the actual com-

Manure.	For permanent experiments.	For temporary experiments.
	Per Ton.	Per Ton.
Nitrate (15·5 % nitrogen)	£9 0 0	£10 10 0
Sulph. am. (20·6 % nitrogen)	12 0 0	11 15 0
*Super. (28 % soluble phosphate)	3 0 0	2 17 6
Basic slag (37 % insoluble phos.)	2 5 0	2 5 0
Bone meal (52 % insoluble phos. and 4 % nitrogen)	5 10 0	5 0 0
Diss. bones (22 % soluble phos., 12 % insoluble phos. and 3 % nitrogen)	5 0 0	5 0 0
Prec. bone phos. (79·4 % insoluble phos.)	...	5 15 0
Phosphatic guano (1·9 % nitrogen, 67 % insoluble phos.)	...	5 0 0
Fish meal (11 % phos. and 8 % nitrogen)	6 10 0	6 0 0
Mur. potash (50 % potash)	9 10 0	9 0 0
Sulph. potash (50 % potash)	10 5 0	10 5 0
Kainit (12 % potash)	2 5 0	2 5 0
Farmyard manure	0 5 0	0 5 0
Lime (lime shells)	0 12 6	0 12 6
Ground lime	1 3 0	1 3 0
Agricultural salt	1 0 0	1 0 0

* Insoluble phosphates in super. are not reckoned.

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* This work is now under the charge of Mr. Bryner Jones.

position has varied in different cases (see page 2). The prices are given as in previous reports for permanent experiments, and as they were in the spring of 1902 for one year's experiments and for others commencing in that year. The prices are about what the different manures would have cost in two ton lots carriage free at railway stations within 20 miles of Newcastle.

The large number of chemical analyses which the experiments involve are made in the chemical laboratory of the College by Mr. Collins.

Soil maps.—A close study of the results of the rotation and other experiments, which have extended over several years, shows that the soils have distinct manurial requirements where they are formed directly from the rock of a geological formation which gives it the distinctive character. At Cockle Park, for example, the stiff Boulder Clay soils respond to phosphoric acid in basic slag, but not to a potash manure, whereas on the sandy Millstone Grit soils of the same farm, potash is found to be almost the most important ingredient in the manure. The College experiments have also shown that the shallow and easily worked reddish soils of the Magnesian Limestone are generally very deficient in phosphates; the light and frequently gravelly soils of the Glacial Sands and Gravels are generally found to be deficient in potash.

The original one-inch geological maps *(drift edition)* are published by Edward Stanford, and are of great service in assisting to locate the soils of the various formations. The quarter-sheets cost about 3s. each. A very useful purpose would be served by having these mounted and placed in libraries or other convenient places for reference at the principal agricultural centres throughout the northern counties. These are not soil maps, however, but simply show the superficial drift deposits (such as Boulder Clay) which cover the great rock formations over such a great area of the North of England. They also show the rock formations themselves where not so covered.

The soil maps published by the United States Department of Agriculture are of a much more complete character, and show the character and depth of the soil as well as the character of the subsoil. Similar maps should be of the greatest service to the English agriculturist.

A full inquiry into the variations in composition of swedes and other roots is now in progress. This report contains the results of Mr. Collins' analyses of these during the past year. Forty-five varieties of swedes have been grown on twelve different farms over the North of England. Members of the agricultural staff choose the land for their growth and sample the swedes for analysis. This work entailed the visiting of these twelve farms at the end of last year and the sampling of forty-five different lots of swedes. A core right through the root is taken from one hundred roots of each lot, so that the amount of time and labour involved is very considerable. Fifty samples of mangels and potatoes have also been taken for analysis. A feeding experiment with sheep fed on different varieties of swedes, which vary widely in composition, was made at Cockle Park last winter, the results of which will be published in the Cockle Park report.

An inquiry into the variations in the composition of milk is now in progress and has been elaborated at the request of the Northumberland County Council, the results of which will probably be published in a special report later on.

All the College experiments dealt with in this report have been originated by my predecessors, Dr. Somerville and Professor Middleton.

DOUGLAS A. GILCHRIST.

Durham College of Science,
Newcastle-upon-Tyne, June, 1903.

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Experiments on Old Land Hay.

(TABLES I. TO VII.)

These experiments are now being made at sixteen centres throughout the three northern counties. Eleven of them have been in progress for from seven to ten years, while five are dealt with for the first time in this report. It will be seen from the report on each centre that a very great variety of soils is being tested, and also that soils formed from the greater number of the geological formations of the north of England are included in the experiments.

Method of tabulating results.—The tables contain particulars (all per acre) of the manuring; the cost of the manures; the yield of hay for season 1902, and the total and average yield of all the years; the average increase over the unmanured plot; and the average annual profit or loss on each plot. In all cases the hay (old land hay) is valued at 50s. a ton. The prices of the various manures are given in the preface.

LESSONS FROM THE EXPERIMENTS.

The nitrogenous manures.—Nitrate and sulph. am. are in many cases not profitable (see especially Cumberland experiments, Set I.), but when they are useful very small dressings are apparently most profitable (Cumberland experiments, Set II.). Sulph. am. gives, on the average, poorer results than nitrate, notably so at Eskdale and at Broomhaugh.

Phosphatic manures are effective at all the centres, and are the most generally useful manures for meadow land. Slag is decidedly the best phosphatic manure for the poor, stiff Boulder Clay soil at Wigton, the results indicating that this is a "slag soil." Slag is also superior to super. on the Boulder Clay loams at Kirkbampton and at Seaham, as well as on the sandy loam at Shield Ash. Half slag and half super. do best on the peat at Glasson and on the light alluvial soil at Castle Carrock; super. is distinctly the best, however, on the sandy Millstone Grit soil at Broomhaugh. Leaving the "slag soils" out of account, bone meal, diss. bones and fish meal have proved themselves useful phosphatic manures, and a combination of all the phosphatic manures is singularly successful on practically all except the heavier soils.

The potash manure.—Kainit is generally fairly useful on all except the slag soils. Used as a single manure, however, it is not effective, but in combination with slag and other manures it is of exceptional value on the sandy Millstone Grit soil at Broomhaugh, and on other similar soils.

Lime gives very poor results on the four centres where it has been tried in Cumberland. Six cwt. per acre, applied in alternate years with artificials, have greatly reduced the crops in all cases. The only successful application of lime for meadow hay is at Broomside House, where the hay is increased for 1902 by 13½ cwt. an acre, 4 tons of lime being applied to this peaty loam soil during the previous winter.

Farmyard manure gives very varied results. On the dry, sandy soil at Broomhaugh it gives a good profit, as well as on the medium loam at Eskdale. It is quite unsuitable, however, for the peat at Glasson, and for the heavier soils with considerable organic matter. The lighter classes of soils, poor in organic matter, are likely to give the best results with this manure.

The geological formation is shown in all these experiments to have quite an important bearing on the manurial needs of the soils formed from them. The "slag soils" are lying for the most part on the stiffest of the Boulder Clays; whereas potash, in addition to phosphates, is necessary, as a rule, on the sandy Millstone Grit and other similar soils.

Manurial residues.—Some interesting figures in connection with these are contained in the report on the Cumberland centres, Set II.

General recommendations for the manuring of meadow land are difficult to make in a complete form over a part of the country where soil and other conditions vary so greatly in character. The table which follows gives the dressings that have been most profitable at each of eleven centres. These particular dressings, however, have not been tested against each other at the various centres but are simply those which, among those tested at each centre, have so far proved the most profitable. The tables, giving the results at the different centres, show clearly the effects of the various dressings tested. Farmers desirous of finding a suitable manure for old land hay should refer to the results at the centres at which they find the soil and other conditions appear to be most like those of their own land.

Time and method of applying manures.—Slag applied in the late autumn will be more effective in the following season than when applied later. If there is a considerable bottom of old foggage on the meadow, harrowing the land with heavy (toothed) chain or other harrows will considerably increase the usefulness of the manure. Slag is ground to a very fine powder and must be fine when sown, because if in the slightest degree lumpy it cannot exert its influence. It should not be sown after rain, when there are little pools of

THE MOST PROFITABLE DRESSINGS AT TEN CENTRES.

(FIGURES PER ACRE.)

entre.	Nature of Soil.	Manures on Best Plot.	Average on Best Plot Annually of			Years under Experiment.
			Hay.	Profit from Manuring.		
			cwt.	s.	d.	
Glasson ...	Peat	1 cwt. nitrate, 1 cwt. slag, 1 cwt. super., 2½ cwt. kainit (annually)	26¾	11	4	8
Castle Carrock	Light alluvial soil on Permian sandstone	Do. do.	33¼	10	8	8
Eskdale ...	Medium loam on Granite ...	2 cwt. super., 2½ cwt. kainit (annually)	33¾	21	9	8
Brampton ...	Deep sandy loam on Permian sandstone	11 lb. nitrate, 33 lb. super., 56 lb. slag, 33 lb. diss. bones, 22 lb. bone meal, 11 lb. fish meal, and 206 lb. kainit (alternate years only)	32	19	11	8
Gosforth ...	Light gravelly soil on Drift	22 lb. nitrate, 66 lb. super., 112 lb. slag, 66 lb. diss. bones, 44 lb. bone meal, 22 lb. fish meal, and 412 lb. kainit (alternate years only)	37¾	14	10	8
Kirkbampton	Loam on Boulder Clay overlying Lias	1 cwt. nitrate, 1½ cwt. super., and 412 lb. kainit (alternate years only)	40½	18	3	8
Wigton ...	Poor stiff clay on Boulder Clay	56 lb. nitrate, 284 lb. slag, and 412 lb. kainit (alternate years only)	37¼	12	10	8
Broomhaugh ...	Poor sandy soil on Millstone Grit	112 lb. nitrate, 400 lb. slag, and 290 lb. kainit (annually)	25¼	16	6	10
Shield Ash ...	Sandy loam on sandstone of Mountain Limestone	248 lb. slag, 107 lb. fish meal, and 206 lb. kainit (annually)	38¼	23	8	7
Seaham ...	Loam on Boulder Clay overlying Magnesian Limestone	4 lb. sulph. of am., 11 lb. nitrate, 94 lb. super., 28 lb. slag, 32 lb. diss. bones, 11 lb. fish meal, and 144 lb. kainit (annually)	33½	14	10	9

water on the land, as the powder falling on the surface of these pools is collected into lumps as the water drains off. Potash manures, as well as bone meal and other insoluble phosphatic manures, are also best applied in the late autumn. Super. may be applied at the same time, or up till the early spring; and nitrate or sulph. am. when spring growth commences. Farmyard manure is best applied in the autumn; this is usually the time when this manure can be most conveniently spared for the meadows, the winter and spring manure being as a rule wanted for root crops.

EFFECTS OF SEASON.

The following figures show the average effects produced in each of the past seven seasons on the unmanured plot and on the best plot of eleven of the stations:—

Year.	Average produce per acre at 11 centres.	
	Unmanured plot.	Best plot.
	Cwt.	Cwt.
1896	18½	30¼
1897	19	35
1898	27	45¾
1899	22½	36
1900	22	42
1901	15½	30½
1902	27¼	44½
Average of 7 seasons at 11 centres.	21½	39

It will be seen that while the season of 1901 was the worst of these seasons for producing hay, the season of 1902 was one of the best of the series, the unmanured plot producing on the average more hay last season than in any of those preceding it. As these stations are representative of the North of England they furnish a fairly correct index of the average yield of old land hay over this part of the country, so that last season the meadow hay crop was more than 25 per cent. over the average, at any rate so far as amount of hay was concerned.

The figures given below give the yields on the unmanured and on the best plots at four of the stations which are situated on a line stretching across the country from the east to the west coast.

Station.	1896.		1897.		1898.		1899.		1900.		1901.		1902.	
	Unmanured plot.	Best plot.	Unmanured plot.	Best plot.	Unmanured plot.	Best plot.	Unmanured plot.	Best plot.	Unmanured plot.	Best plot.	Unmanured plot.	Best plot.	Unmanured plot.	Best plot.
	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
Seaham ...	23	41	10¼	21	38	54½	24	37	17½	39½	21½	42¾	24¾	40½
Shield Ash ...	20¼	32½	22½	37	24¾	54¾	24¼	50¼	23¾	50½	17¾	34¾	25	37¼
Castle Carrock	15	31	22¼	46¼	30¾	46	22	39½	21	48	6¼	19¾	28	50½
Eskdale ...	14¼	34¾	17¼	41½	16¼	33¼	27	48½	22¾	45½	12	45¾	33¾	39¼

The drought in 1901 and the good effects of last season have evidently been felt to a much greater extent in the west than they were in the east.

CUMBERLAND OLD LAND HAY EXPERIMENTS (SET I.)

The complete results of these experiments for eight years, 1895-1902, are contained on Table I., page 19. This table gives most interesting results, which can readily be grasped by a reference to it, as the cost of the manures, the average annual increase over the unmanured plot, and the average annual profit or loss are given for each plot.

Centres and character of soil.—These are as follows:—

Centre.	Occupier.	Nature of soil.
Blencow	Mr. M. Walker	Clay loam on Old Red Sandstone
Glasson	Mr. G. Graham	Peat
Gelt Mill, Castle Carrock ...	Mr. J. W. Steele	Light alluvial soil on Permian sandstone
Muncaster Head, Eskdale ...	Mr. T. Troughton	Medium loam on Granite

Objects of experiments.—The chief object is to determine the relative value of nitrogen, phosphates and potash for producing hay on these soils. In addition, slag and super. are compared as phosphatic manures, and nitrate and sulph. am. as nitrogenous manures. A test is also made of the comparative value of dung and artificials.

NOTES ON RESULTS.

The Blencow results are not taken into account in the following notes, as the soil at that centre is not quite uniform.

Complete v. partial manuring.—The effects of this are as follows (all per acre):—

Plot.	Manures.	Average annual cost of manure.	Average annual profit.		
			Glasson.	Castle Carrock.	Eskdale.
		s. d.	s. d.	s. d.	s. d.
9	Complete (nitrogen, phosphates, potash)	21 0	4 0	6 6	18 4
8	Phosphates and potash only ...	12 0	6 1	8 0	21 9
7	Nitrogen and potash only	14 10	-1 9	5 9	12 0
6	Nitrogen and phosphates only ...	15 2	7 11	-6 5	4 2

Phosphates and potash only give on the average a return of over 2s. an acre more than the *same manures with nitrogen.* The results on plot 8, which had super. and kainit, and on plot 9, which had the same with nitrate, show that this is so.

Professor Middleton has found that the feeding value of hay. grown from phosphates and potash only, was over 7 per cent. greater than that grown with the same manures to which sulph. am. was added (Cockle Park Report, 1901). As it is likely that nitrate has somewhat the same effect as sulph. am. the difference in the annual profit per acre is still more in favour of plot 8, if the hay is used for home feeding.

Nitrogen and potash only (plot 7) give good results on the light alluvial soil at Castle Carrock and also on the medium loam at Eskdale, thus indicating that a potash manure is wanted at these centres. This is confirmed by plot 6, on which the absence of potash results in a considerable loss at Castle Carrock and reduces the profit very much at Eskdale. On the peat soil at Glasson, however, the profit is not thereby reduced.

Superphosphate v. slag.—These are compared on plots 9, 10 and 11.

Plot.	Manure.	Average annual cost of manure.	Average annual profit.		
			Glasson.	Castle Carrock.	Eskdale.
		s. d.	s. d.	s. d.	s. d.
9	Complete manure, phosphates in super.	21 0	4 0	6 6	18 4
10	Complete manure, phosphates in slag	18 10	8 8	6 9	18 8
11	Complete manure, phosphates half in super., half in slag	19 11	11 4	10 8	16 4

These results show on the whole no great difference in the effects of super. and of slag at these centres, but there is a slight balance of advantage for half super. and half slag on plot 11. Slag is more profitable on the peat soil at Glasson, but half slag and half super. is still better at that centre.

Nitrate of soda v. sulphate of ammonia.—These are compared on plots 10 and 12.

Plot.	Manure.	Average annual cost of manure.	Average annual profit.		
			Glasson.	Castle Carrock.	Eskdale.
		s. d.	s. d.	s. d.	s. d.
10	Complete manure, nitrogen as nitrate	18 10	8 8	6 9	18 8
12	Complete manure, nitrogen as sulph. am.	18 10	8 8	3 0	4 3

At Castle Carrock and at Eskdale sulph. am. gives much poorer results than nitrate. On the peat soil at Glasson the results are equal. The experiments, therefore, at these centres show that while neither of these manures have been profitable, sulph. am. has given much worse results on the whole than nitrate.

Half dressing of artificials.—Comparing plots 12 and 14 it is found that half the artificials of plot 12, applied to plot 14, gives a considerably better result at Castle Carrock and at Eskdale, the annual profit being three times as great from the half dressing at these centres. At Glasson, however, the result is in the opposite direction. At many other centres the lighter annual dressings of manure are often the most profitable.

Farmyard manure and artificials.—Dung only (ten tons), applied in alternate years on plot 16, gives a good annual profit (15s. 8d. an acre) on the medium loam at Eskdale, but is not profitable at the other centres. It is evidently not a suitable manure for the peat at Glasson, nor for the alluvial soil at Castle Carrock. On plot 13, 10 tons dung in alternate years, with a half dressing of artificials, is not a success at any of the centres, although elsewhere this frequently proves to be profitable. On plot 15, however, where the same artificials and dung are applied, but in the same years and nothing in the alternate years, a good annual profit is given at Castle Carrock and at Eskdale, but there is a considerable annual loss at Glasson. The results with dung are, therefore, very variable in character, its worst results being on the peat at Glasson, which is, of course, already overstocked with organic matter.

PLOTS 1/10-ACRE. FIGURES PER ACRE.

Plot.	Manures for 1895-1902 (slightly different 1895).						Average annual cost of manures.	Yield of Hay.																				Plot.
								Blencow.					Glasson.					Gelt Mill, Castle Carrock.					Muncaster Head, Eskdale.					
	Dung.	Sulph. Am.	Nitrate.	Super.	Slag.	Kainit.		1902.	Eight years, 1895-1902.	Average of eight years.	Average increase or decrease (-) over unmanured plot.	Average annual profit or loss (–).	1902.	Six years, 1895-1902 (see note).	Average of six years.	Average increase over manurial plot.	Average annual profit or loss (–).	1902.	Eight years, 1895-1902.	Average of eight years.	Aver. increase over unmanured plot.	Average annual profit or loss (–).	1902.	Eight years, 1895-1902.	Average of eight years.	Aver. increase over unmanured plot.	Average annual profit or loss (–).	
	Tns	lb.	lb.	lb.	lb.	lb.	s. d	Cwt	Cwt.	Cwt	Cwt.	s. d.	Cwt	Cwt.	Cwt	Cwt	s. d.	Cwt	Cwt.	Cwt	Cwt	s. d.	Cwt	Cwt.	Cwt	Cwt	s. d.	
1	..	..	..	..	..	..	..	35¾	184½	23	..	..	31¾	85½	14¼	..	..	28	168	21	..	..	33¾	161½	20¼	..	..	1
2	..	..	109	..	..	..	9 0	39	222¾	28	5	3 6	27	88¼	14¾	¼	− 7 9	26¾	205¼	25¾	4¾	2 10	34¼	195¼	24½	4¼	1 7	2
3	..	..	..	230	..	..	6 2	38	251½	31½	8½	15 1	34	111½	18½	4¼	4 5	23¼	179	22½	1½	−2 5	34½	202¼	25¼	5	6 4	3
4	..	..	..	..	200	..	4 0	36½	134¼	16¾	−6¼	−20 10	26	99¾	16½	2¼	1 7	26	176½	22	1	−1 6	27½	174½	21¾	1½	−0 3	4
5	..	..	..	..	..	290	5 10	41½	235¾	29½	6½	10 5	29½	111¾	18¾	4½	5 5	33¾	201¾	25¼	4¼	4 9	32¾	181½	22¾	2½	0 5	5
6	..	..	109	230	..	..	15 2	39¾	255	32	9	7 4	33½	141	23½	9¼	7 11	32	196½	24½	3½	−6 5	27¼	225	28	7¾	4 2	6
7	..	..	109	..	..	290	14 10	41¼	239	30	7	2 8	34¼	116¾	19½	5¼	− 1 9	38¾	234¾	29¼	8¼	5 9	38	248	31	10¾	12 0	7
8	..	..	..	230	..	290	12 0	49¼	215½	27	4	− 2 0	34½	129½	21½	7¼	6 1	49¾	231¾	29	8	8 0	38¼	269¼	33¾	13½	21 9	8
9	..	..	109	230	..	290	21 0	50¾	238	29¾	6¾	− 4 2	26¾	145½	24¼	10	4 0	39¾	235	32	11	6 6	38¾	287¼	36	15¾	18 4	9
10	..	..	109	..	200	290	18 10	48¼	237¼	29¾	−6¾	− 1 11	39	151½	25¼	11	8 8	44¾	249½	31¼	10¼	6 9	37½	282½	35¼	15	18 8	10
11	..	..	109	115	100	290	19 11	36½	225½	28¼	−5¼	− 6 10	42½	160	26¾	12½	11 4	48	266¾	33¼	12¼	10 8	39¼	277¼	34¾	14½	16 4	11
12	..	84	..	..	200	290	18 10	36¼	214¾	26¾	3¾	− 9 6	37¾	151½	25¼	11	8 8	44¼	238½	29¾	8¾	3 0	36	235½	29½	9¼	4 3	12
13	10*	42*	..	..	100*	145*	29 8	38½	206½	25¾	2¾	−22 10	40	138¾	23	8¾	− 7 10	50½	278	34¾	13¾	4 8	34¾	237¾	29¾	9½	−5 11	13
14	..	42	..	..	100	145	9 .5	44½	207¼	26	3	− 1 11	37	120¾	20	5¾	4 11	42	227½	28½	7½	9 4	32¼	231¾	29	8¾	12 6	14
15	10†	42†	..	..	100†	145	29 8	40¾	240¼	30	7	−12 2	36¼	127¾	21¼	7	−12 2	44	285½	35¾	14¾	7 2	36½	302½	37¾	17½	14 1	15
16	10‡	..	..	..	..	..	25 0	41¾	227¼	28½	5½	−11 3	44½	146¼	24¾	10½	1 3	42½	240¼	30	9	−2 6	32	291	36½	16¼	15	16

* Plot 13 got dung only in 1896, artificials only in 1897, and so on in alternate years. † Plot 15 got dung and artificials in 1895, and in alternate years only thereafter.
‡ Plot 16 got Dung in 1895, and in alternate years only thereafter (applied at Glasson in 1900 by mistake.) Plot 14 got 84 lb. sulph. am. in 1900.
The hay at Glasson was not weighed in 1897 nor 1900. All the plots at Glasson got a light dressing of dung in the autumn of 1901.
Plots 9-12 receive standard dressing of 17·5 lb. nitrogen, 35 lb. phos. acid, and 35 lb. potash per acre.

CUMBERLAND OLD LAND HAY EXPERIMENTS (SET II.).

The results of this set are contained in Table II., page 26. Full details are given on this table of the plan of manuring, of the results of the eight years (1895-1902), and of the profit or otherwise from the various combinations of manures.

CENTRES AND CHARACTER OF SOILS.

Centre.	Occupier.	Nature of soil.
Castlesteads, Brampton	Mr. J. P. Johnson ...	Deep sandy loam on Permian sandstone.
Park Nook, Gosforth ...	Dr. Parker	Light gravelly soil on Drift.
Fold House, Kirkbampton	Mr. J. Holliday ...	Loam on Boulder Clay overlying Lias.
Percy Hill, Wigton ...	Mr. H. W. Pallister	Poor stiff clay on Boulder Clay.

Objects of experiments.—These are (1) to ascertain in what proportion the three ingredients of a complete manure should be mixed; (2) to compare the effects of the phosphatic manures, super., basic slag, diss. bones and bone meal; (3) to compare fish meal with other dressings; (4) to ascertain the effects of supplying nitrogen and phosphates from several sources in one dressing instead of in one manure only, respectively; (5) to test the effect of adding lime to artificial manures.

NOTES ON RESULTS.

It is important to note that the manures are practically applied in alternate years only in this set of experiments.

Variations in amount of nitrogen, phosphates and potash.—The following figures show the effects of varying the amount of these constituents:—

Plot.	Manuring for 1895, '97, '98, 1900 and 1902.	Average annual cost of manure.	Average annual profit.			
			Brampton.	Gosforth.	Kirk-bampton.	Wigton.
		s. d.	s. d.	s. d.	s. d.	s. d.
2	1 cwt. nitrate, 3 cwt. super., 3¾ cwt. kainit (standard dressing)	16 5	-0 2	9 2	11 8	-3 4
3	50% *less super.* than standard	13 7	-0 6	-1 1	18 3	-3 7
4	50% *more super.* than standard	19 2	-1 8	7 1	2 8	2 8
5	50% *less kainit* than standard	13 10	0 6	2 11	0 6	6 9
6	50% *more kainit* than standard	19 0	2 3	0 4	5 4	4 9
7	50% *less nitrate* than standard	13 7	12 8	3 11	4 6	2 4
8	50% *more nitrate* than standard	19 2	5 10	5 2	7 1	3 4

From these figures no conclusions of a satisfactory character can be drawn. At Kirkbampton the heavier dressings of super. are evidently doing harm, as the result with the half dressing of super. is so good at that centre; on the other hand the heavier dressings of super. give considerably the best results on the light gravelly soil at Gosforth. The results with more or less nitrate or kainit are so contradictory that no conclusions can be drawn from them.

Effects of different phosphatic manures and of a complex mixture.

Super. and slag are compared on plots 7 and 9. On the poor clay soil (evidently a "slag soil"), at Wigton, slag gives a handsome profit; whereas super. gives a small return; slag also gives double the return of super. on the Boulder Clay loam at Kirkbampton. The results are about equal at Brampton and Gosforth where both manures give good returns. A *double dressing of slag* increases the profit by one-half at Brampton, but is not more profitable at the other centres.

Plot.	Manuring for 1895, '97, '98, 1900 and 1902.	Average annual cost of manures.	Average annual profit.			
			Brampton.	Gosforth.	Kirk-bampton.	Wigton.
		s. d.	s. d.	s. d.	s. d.	s. d.
7	Complete manure with super.	13 7	12 8	3 11	4 6	2 4
9	Complete manure with slag	11 6	11 0	4 1	9 1	12 10
10	Complete manure with double slag	13 3	16 1	1 9	6 2	11 1
11	Complete manure with diss. bones	14 3	9 6	7 7	2 7	4 6
12	Complete manure with bone meal	12 0	4 10	9 10	7 4	10 6
13	Complete manure with fish meal and slag	12 2	9 8	5 11	4 8	3 5
14	Complete manure containing ⅕th dressings to plots 7, 9, 11, 12, 13	12 8	17 4	14 10	17 11	2 11
15	Half of dressing applied to plot 14	6 4	19 11	–0 9	6 2	6 2

Diss. bones, on plot 11, are distinctly behind either slag or super. at all the centres except Gosforth, but at the same time they give a fair profit in every case. *Bone meal* also gives good results generally (plot 12), and, although not as good as either slag or super. at Brampton, Kirkbampton or Wigton, it does better than either of these manures at Gosforth. *Fish meal and slag* give a good result at Brampton and a fair, but not large, profit at the other three stations. These manures are in all cases added to the same amount of kainit, and sufficient nitrate, when required, to make up the standard amount of nitrogen.

The *complex manure*, supplying nitrogen and phosphates from various sources, gives by far *the best results* at three centres, but does not do so at Wigton. It should be noted that the potash manure is of the same kind and amount as it is on plots 7, 9, 11, 12 and 13, so that it is only the part of the dressing containing nitrogen and phosphates which is complex in character. This complex manure gives on plot 14 one of the most useful and striking results of all the old land hay trials. Probably the mixture of soluble and insoluble nitrogen and of soluble and insoluble phosphates has done much to keep the crop growing steadily, but, whatever be the reason, this plot, receiving one-fifth of each of the other plots indicated, gives at three out of four centres a result far better than on any of these five plots. It is important to note that this plot receives only one-fifth of a cwt. of nitrate per acre, the rest of the nitrogen being in an insoluble form in the other manures. The success of this dressing containing such a small amount of nitrate goes far to corroborate the Cumberland (Set I.) experiments as to nitrate not being profitable for old land hay. While the complex manure does well on the sandy loam at Brampton, on the gravelly soil at Gosforth, and on the loam at Kirkbampton it is not a success on the poor clay, lying on Boulder Clay, at Wigton, which latter is evidently a "slag soil" as is indicated by the excellent result with slag (plot 9) at that centre.

The *half-dressing of artificials* on plot 15 is not on the whole a success, although it gives an excellent result at Brampton.

Six cwt. of lime added to artificials (plot 16) gives uniformly bad results, as is shown by the following:—

Plot.	Manuring.	Average annual cost.	Average annual profit or loss (–).			
			Brampton.	Gosforth.	Kirkbampton.	Wigton.
		s. d.	s. d.	s. d.	s. d.	s. d.
15	Half dressing of artificials	6 4	19 11	– 0 9	6 2	6 2
16	Half dressing of artificials and 6 cwt. lime	10 3	1 7	– 9 8	4 1	–7 9

Manurial residues.—In this set of experiments the manures have been applied for seasons 1895, 1897, 1898,

Plot.	Manuring.	Average increase or decrease (–) compared with the unmanured plot at							
		Brampton.		Kirkbampton.		Gosforth.		Wigton.	
		Manure applied.	Manure withheld.	Manure applied.	Manure withheld.	Manure applied.	Manure withheld.	Manure applied.	Manure withheld.
		Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
7	½ cwt. nit. soda 3 „ super. 3½ „ kainit	13¼	5¾	10¾	¾	11	–2½	8	–1½
9	½ cwt. nit. soda 2½ „ slag 3½ „ kainit	10	6¾	10½	4	10	–3	13½	3¼
11	3 cwt. dis. bones 3½ „ kainit	10¼	4¾	8¾	2¼	12	1½	12	½
12	2 cwt. bone meal 3½ „ kainit	8	5	9¾	4	11¼	2½	11½	4¾
13	1 cwt. fish meal 2¼ „ slag 3½ „ kainit	10	7¼	9¾	2	10¼	0	9¼	1
14	⅕ of collective dressings of above plots	14¾	7½	16	5	14½	2¼	10	–½
	Average of six plots	11¾	6¼	10¾	3	11½	–¾	10¾	1¼

1900 and 1902; and withheld for seasons 1896, 1899 and 1901. The above table shows the average annual increase on six of the plots over the unmanured plots during the five years in which the manures were applied and the three years in which they were not applied. The hay was not weighed at Gosforth for 1901, so that the figures under "manure withheld" at that centre are the averages of two years only.

From these figures it will be seen that there is considerable variation in the "residue increase" during years when the manures were withheld, but that this variation is due largely to soil conditions. The various dressings of manures give a very even "residue increase" at the different centres. On the deep, sandy loam at Brampton the increased yield for the years when the soils were unmanured is more than half of that for the years they were manured; on the loam at Kirkbampton it is less than one-third; on the light gravelly soil at Gosforth there is no increased yield during two of the years the soils were unmanured, and on the poor clay at Wigton the crop of the years when the plots were unmanured is less than one-eighth of that of the years the manures were applied.

TABLE II.—EIGHT YEARS OF CUMBERLAND HAY (OLD LAND) EXPERIMENTS, 1895-1902 (SET II.).

PLOTS $\frac{1}{20}$-ACRE. FIGURES PER ACRE.

Plot.	Manures for 1895, 1897, 1898, 1900 and 1902. Nitrate.	Super.	Slag.	Diss. bones.	Bone meal.	Fish Meal.	Kainit.	Lime.	Average annual cost of manures.	Yield of Hay. Castlesteads, Brampton. 1902.	8 years 1895-1902.	Average of 8 years.	Average increase over unmanured plot.	Average annual profit or loss (–).	Park Nook, Gosforth. 1902.	7 years, 1895-1902 (not weighed 1901)	Average of 7 years.	Average increase over unmanured plot.	Average annual profit or loss (–).	Fold House, Kirkbamp'n. 1902.	8 years, 1895-1902	Average of 8 years.	Average increase over unmanured plot	Average annual profit or loss (–).	Percy Hill, Wigton. 1902.	8 years, 1895-1902.	Average of 8 years.	Average increase over unmanured plots.	Average annual profit or loss (–)	Plot.
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	s. d.	Cwt	Cwt.	Cwt	Cwt	s. d.	Cwt	Cwt	Cwt	Cwt	s. d.	Cwt	Cwt.	Cwt	Cwt	s. d.	Cwt	Cwt.	Cwt	Cwt	s. d.	
1	..	..	..	..	..	..	..	..	..	22½	171¼	21½	..	..	34½	187½	26¾	..	..	25	222¾	27¾	..	..	33	220¼	27½	..	..	1
2*	109	328	..	..	..	..	412	..	16 5	31¾	224¼	28	6½	–0 2	60¾	258¾	37	10¼	9 2	36¼	311	39	11¼	11 8	45	262	32¾	5¼	– 3 4	2*
3	109	164	..	..	..	..	412	..	13 7	36¼	214¾	26¾	5¼	–0 6	48½	222½	31¾	5	– 1 1	43¾	323¾	40½	12¾	18 3	42¾	252¾	31½	4	– 3 7	3
4	109	492	..	..	..	..	412	..	19 2	38¼	227¼	28½	7	–1 8	60¼	261¼	37¼	10½	7 1	34¾	292	36½	8¾	2 8	42¼	290¾	36¼	8¾	2 8	4
5	109	328	..	..	..	..	206	..	13 10	35¼	217¼	27¼	5¾	0 6	52	235	33½	6¾	2 11	30¼	268¼	33½	5¾	0 6	40¾	285¾	35¾	8¼	6 9	5
6	109	328	..	..	..	..	618	..	19 0	38¼	239½	30	8½	2 3	53¼	240¾	34½	7¾	0 4	39¼	300	37½	9¾	5 4	39¾	295¼	37	9½	4 9	6
7	54½	328	..	..	..	..	412	..	13 7	42½	256	32	10½	12 8	55¼	236¾	33¾	7	3 11	35	280	35	7¼	4 6	39	256	32	4½	2 4	7
8	163½	328	..	..	..	..	412	..	19 2	34½	251½	31½	10	5 10	62¾	256¼	36½	9¾	5 2	38½	306¼	38¼	10½	7 1	47¾	292¾	36½	9	3 4	8
9	54½	..	284	..	..	..	412	..	11 6	35	243¼	30½	9	11 0	47½	230½	33	6¼	4 1	35¼	287¼	36	8¼	9 1	44½	298¼	37¼	9¾	12 10	9
10	54½	..	426	..	..	..	412	..	13 3	39¼	266¾	33¼	11¾	16 1	41½	229	32¾	6	1 9	33	285	35½	7¾	6 2	41¾	297¼	37¼	9¾	11 1	10
11	..	..	..	326	..	..	412	..	14 3	29½	237¾	29¾	8¼	6 5	51	249	35½	8¾	7 7	35¾	275½	34½	6¾	2 7	41¾	279¾	35	7½	4 6	11
12	..	..	..	..	223	..	412	..	12 0	30¾	226¾	28¼	6¾	4 10	51	249	35½	8¾	9 10	34½	284¾	35½	7¾	7 4	39¾	291¾	36½	9	10 6	12
13	..	..	248	..	..	107	412	..	12 2	27¾	243	30¼	8¾	9 8	44½	238	34	7¼	5 11	32	277	34½	6¾	4 8	39½	270½	33¾	6¼	3 5	13
14†	22	66	107	65	45	21	412	..	12 8	39¾	269	33½	12	17 4	53	264½	37¾	11	14 10	37¾	319½	40	12¼	17 11	41¾	269¼	33¾	6¼	2 11	14†
15	11	33	53½	32½	22½	10½	206	..	6 4	39	256	32	10½	19 11	41¾	203¾	29	2¼	– 0 9	32	261¼	32¾	5	6 2	37	261	32½	5	6 2	15
16	11	33	53½	32½	22½	10½	206	700¼	10 3	30	210½	26¼	4¾	1 7	35	189½	27	¼	– 9 8	33	267½	33½	5¾	4 1	33	227¼	28½	1	– 7 9	16

* This dressing supplies 17½ lb. nitrogen, 50 lb. phosphoric acid and 50 lb. potash.

BROOMHAUGH OLD LAND HAY EXPERIMENT.

Table III., page 28, contains a summary of the results for ten years of an experiment on the manuring of old land hay on Mr. C. Marshall's farm, Broomhaugh, Riding-Mill-on-Tyne.

Soil.—This is poor, light and very sandy in character, and lies on the Millstone Grit.

NOTES ON RESULTS.

Effects of artificials, and of omission of nitrogen, phosphates, or potash.—The following figures show striking results:—

Plot.	Manuring.	Average yield in 10 years. 1893-1902.	Average annual profit.	
		Cwt.	s.	d.
1	No manure	10	...	
8	Complete artificials	25¼	16	6
7	Artificials without nitrogen	21¼	14	7
6	Artificials without phosphates	13¾	5	0 (loss)
5	Artificials without potash	17¼	2	9

These figures show that the omission of nitrate from the artificials reduces the profit to a very small extent, but when either phosphates or potash are omitted there is practically no profit from the other manures applied. The need of both phosphates and potash is most characteristic of the light, sandy Millstone Grit soils.

Effects of nitrate of soda and sulphate of ammonia.—These are shown as follows:—

Plot.	Manuring.	Average yield in 10 years. 1893-1902.	Average annual profit.
		Cwt.	s. d.
1	No manure … … … … …	10	…
2	1 cwt. nitrate … … … … …	13¾	1 3
8	Artificials with nitrate … … …	25¼	16 6
9	Artificials with sulph. am. … … …	18¾	0 3

TABLE III.—TEN YEARS OF EXPERIMENT ON OLD LAND HAY AT BROOMHAUGH, NORTHUMBERLAND, 1893-1902. (B. PLOTS.)

PLOTS $\frac{1}{40}$-ACRE. FIGURES PER ACRE.

Plot.	Manures applied annually.						Average annual cost of manures.			Amount of hay.				Average annual profit or loss (–).	
	Dung.	Sulph. am.	Nitrate	Super.	Slag.	Kainit.				1902.	Ten years, 1893-1902.	Average of ten years.	Average increase over unmanured plot.		
	Tons.	lb.	lb.	lb.	lb.	lb.	£	s.	d.	Cwt.	Cwt.	Cwt.	Cwt.	s.	d.
1	…	…	…	…	…	…		…		7	99¼	10	…	…	
2	…	…	109	…	…	…	0	8	1	12	138	13¾	3¾	1	3
3	…	…	…	…	400	…	0	7	3	15¾	135	13½	3½	1	6
4	…	…	…	…	…	290	0	6	3	12¼	102	10¼	¼	–5	8
5	…	…	109	…	400	…	0	15	4	21	171¾	17¼	7¼	2	9
6	…	…	109	…	…	290	0	14	4	15	137	13¾	3¾	–5	0
7	…	…	…	…	400	290	0	13	6	21	213	21¼	11¼	14	7
8	…	…	109	…	400	290	1	1	7	26¼	251¼	25¼	15¼	16	6
9	…	84	…	…	400	290	1	1	7	21½	186¼	18¾	8¾	0	3
10	…	…	109	230	…	290	1	1	1	24¾	197½	19¾	9¾	3	3
11	10*	…	…	…	…	…	1	10	0	30¾	260	26	16	10	0

* Plot 11 got dung in 1893, 1894 and alternate years thereafter.

NOTES.—The standard dressing, in lb. per acre, consists of:—nitrogen, 17·5 lb., phosphoric acid, 70 lb. (except plot 10 which receives 35 lb. only), and potash, 35 lb.

In 1893 and 1894 the artificial dressings were:—1 cwt. nitrate, ¾ cwt. sulph. am., 4½ cwt. slag, 3 cwt. super., and 5 cwt. kainit.

No manure was applied in 1895.

Nitrate alone gives a very small annual profit, while *sulph. am.*, as part of the complete artificials, has a very bad effect.

Phosphates alone, on plot 3, and *potash alone,* on plot 4, give poor results. On plot 10, where *super. takes the place of slag* in the complete artificials, the result is decidedly in favour of slag. There is only half the phosphoric acid in the former that there is in the slag, but the money value of the super. is nearly as great.

Dung, on plot 11, shows a profit of 10s. annually.

The most striking result at this centre is the great need for potash as well as phosphates; in contrast to the heavier Boulder Clay and other heavy soils, which generally respond readily to slag without the addition of a potash manure.

SHIELD ASH OLD LAND HAY EXPERIMENT.

The results on Table IV., page 32, are those of an experiment on the manuring of old land hay on Mr. J. Robinson's farm, Shield Ash, Weardale.

Soil.—This is a sandy loam lying on a sandstone of the Mountain Limestone.

NOTES ON RESULTS.

Effects of complete artificials and of omission of one manurial ingredient.

Plot.	Manuring.	Average annual cost of manure.	Average yield in 7 years. 1896-1902.	Average annual profit.
		s. d.	Cwt.	s. d.
1	No manure	...	22½	...
5	Complete artificials	17 8	34¾	13 0
4	Artificials without nitrogen ...	13 2	31¾	10 0
3	Artificials without phos. ...	8 8	30	10 1
2	Artificials without potash ...	13 6	30½	6 6

The omission of potash reduces the profit to the greatest extent, but the omission of either phosphates or nitrogen also makes an appreciable difference. Here, as at Broomhaugh, it is evident that potash is very deficient.

Nitrate and sulph. am. are compared on plots 5 and 6, which show a small advantage for nitrate.

Super., slag, and diss. bones are compared on plots 6, 7 and 8; slag gives considerably the best result and super. is better than diss. bones. *Slag and fish meal* (with kainit), on plot 9, give an annual profit of 23s. 8d., being the best result of all the plots. *Bone meal*, on plot 10, has done well, and one-fourth of the collective dressings of plots 5-8, on plot 11, gives the second best result and better than the average of the four plots. *The double dressing of slag* on plot 12 has a remarkably good effect, even although it is not accompanied with a potash manure and indicates that the larger dressing of slag is the more profitable. This result would probably be even better if a potash manure were added to the slag. The question naturally arises here:—Has the lime of the slag liberated some of the soil potash?

The dung plots, on the whole, do well. Five tons applied annually are more effective than 10 tons applied in alternate years (plots 14 and 15); 10 tons dung applied alternately with the artificials of plot 11 are very effective (plot 16); but 10 tons dung applied alternately with slag do not give such a good result (plot 13).

TABLE IV.—SEVEN YEARS OF EXPERIMENT ON OLD LAND HAY AT SHIELD ASH, WEARDALE, CO. DURHAM, 1896-1902.

PLOT $\frac{1}{20}$-ACRE. FIGURES PER ACRE.

Plot.	Manures applied annually.											Amount of Hay.				Average annual profit.		Plot.
	Dung.	Sulph. am.	Nitrate.	Super.	Slag.	Diss. bones.	Bone meal.	Fish meal.	Kainit.	Average annual cost of manures.		1902.	Seven years, 1896-1902.	Average in seven years.	Average increase over unmanured plot.			
	Tons.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	s.	d.	Cwt.	Cwt.	Cwt.	Cwt	s.	d.	
1	..	...	...	...	...	...	...	...	...	...		25	158¼	22½	...	...		1
2	...	...	54	328	...	...	...	...	...	13	6	30¾	213½	30½	8	6	6	2
3	...	...	54	...	...	...	...	...	206	8	8	33	209	30	7½	10	1	3
4	...	...	...	328	...	...	...	...	206	13	2	34¼	222½	31¾	9¼	10	0	4
5	...	...	54	328	...	...	...	...	206	17	8	36	242½	34¾	12¼	13	0	5
6	...	42	...	328	...	...	...	...	206	17	8	35	240	34¼	11¾	11	8	6
7	...	42	...	...	284	...	...	...	206	14	3	33¾	238	34	11½	14	6	7
8	...	...	...	...	...	328	...	...	206	19	2	32¾	227¼	32½	10	5	10	8
9	...	...	...	...	248	...	...	107	206	15	8	29½	267¾	38¼	15¾	23	8	9
10	...	...	...	...	...	...	208	...	206	14	6	29¾	250½	35¾	13¼	18	7	10
11	...	21	13	164	71	82	...	...	206	17	2	29	268	38¼	15¾	22	2	11
12	...	...	...	...	568	...	...	...	...	11	3	25¾	237	34	11½	17	6	12
13	10*	...	...	...	568*	...	...	...	...	33	5	33¾	276¾	39½	17	9	1	*13
14	5	...	...	...	...	...	...	...	...	25	0	35½	265¼	38	15½	13	9	14
15	10†	...	...	...	...	...	...	...	...	28	6	31	244	35	12½	2	9	15
16	10‡	21‡	13‡	164‡	71‡	82‡	...	...	206‡	31	3	37¼	296	42¼	19¾	18	1	16

NOTES.—Plots 5, 6, 7, 8, 9 and 11, receive the standard dressing of 8·75 lb. nitrogen 50 lb. phosphoric acid, and 25 lb. potash; plot 11 receives ¼ of the collective dressings of plots 5, 6, 7 and 8. Before 1900 the standard dressing was slightly different (see previous reports).

* Plot 13 got dung only 1896, slag only 1897, and so on in alternate years.

† Plot 15 got dung in 1896, and in alternate years thereafter.

‡ Plot 16 got artificials only 1896, dung only 1897, and so on in alternate years.

SEAHAM OLD LAND HAY EXPERIMENT.

This experiment on the manuring of old land hay is being made on the Seaham Harbour Stud Company's land at Carr House farm, Seaham Harbour. Particulars are contained on Table V., page 34.

The soil is a medium loam, and lies on a subsoil of Boulder Clay which overlies the Magnesian Limestone.

The results are not of a very satisfactory character, owing probably to considerable variation in the nature of the soil on the different plots. *Heavy dressings of super. and of kainit* (plots 3 and 4) give very bad results, the kainit actually greatly decreasing the crop, especially in the later years. Bad results, however, from the continued heavy dressings of these manures, especially of kainit, are not at all uncommon and should be guarded against. In all cases where more than 2 cwt. super. per acre is supplied annually the result is a loss. As a phosphatic manure, basic slag is better than super. (plots 9 and 10), but the combination of the two manures does considerably better than either alone (plot 13). The complicated dressing on plot 17 gives a small profit, but it is interesting and useful to note that the half of this dressing on plot 18 (containing half only of standard dressing) gives quite a large annual profit, thus showing that on this soil comparatively light annual dressings are likely to be most profitable. On plot 19 the same dressing, given in alternate years with 10 tons dung in the intervening years, has not done so well, but 10 tons dung only, applied in alternate years (plot 20) has given quite a satisfactory result.

A botanical analysis of the herbage of the different plots will be made in the near future.

TABLE V.—NINE YEARS OF EXPERIMENT ON OLD LAND HAY AT SEAHAM, CO. DURHAM, 1894-1902.

PLOTS $\frac{1}{20}$-ACRE. FIGURES PER ACRE.

Plot.	Manures for 1894-1902, but nothing in 1895.									Amount of crop.								Plot.
	Dung.	Sulph. am.	Nitrate of soda.	Super.	Slag.	Dis. bones.	Fish meal.	Kainit.	Lime dust.	Average annual cost of manures.		1902.	Nine years, 1894-1902.	Average of 9 years.	Average increase over unmanured plot.	Average annual profit or loss (–).		
	Ton.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	s.	d.	Cwt.	Cwt.	Cwt.	Cwt.	s.	d.	
1	...	...	...	...	...	...	...	...	...	...		24¾	220¾	24½	...	...		1
2	...	...	109	...	...	...	...	...	...	8	0	28½	262½	29¼	4¾	3	10	2
3	...	...	...	656	...	...	...	...	...	16	0	22	220	24½	...	–16	0	3
4	...	...	...	...	...	...	...	580	...	9	10	15¼	203¼	22½	2 decrease	–14	10	4
5	...	...	54	328	...	...	...	...	...	12	0	23½	259½	28¾	4¼	– 1	4	5
6	...	...	54	...	284	...	...	...	...	9	0	26¾	244¾	27¼	2¾	– 2	1	6
7	...	...	54	...	...	...	...	290	...	9	0	27½	237½	26½	2	– 4	0	7
8	...	...	54	328	...	...	...	...	350	15	6	29	243	27	2½	– 9	3	8
9	...	...	54	328	...	...	...	290	...	17	0	28¼	248¼	27½	3	– 9	6	9
10	...	...	54	...	284	...	...	290	...	13	3	33¼	277¼	30¾	6¼	2	4	10
11	...	...	...	328	...	...	...	290	...	13	0	22¼	242¼	27	2½	– 6	9	11
12	...	...	36	219	...	...	...	145	...	10	5	22¾	272¾	30¼	5¾	4	0	12
13	...	...	54	164	142	...	...	290	...	15	5	29	311	34½	10	9	7	13
14	...	...	...	...	...	326	...	290	...	18	0	28½	282½	31½	7	– 0	6	14
15	...	...	...	286	...	...	107	280	...	16	0	29	271	30	5½	– 2	3	15
16	...	42	...	328	...	...	...	290	...	17	0	26¾	258¾	28¾	4¼	– 6	4	16
17	...	8½	22	188	57	65	21½	288	...	15	4	33¼	289¼	32¼	7¾	4	0	17
18	...	4¼	11	94	28½	32½	10¾	144	...	7	8	32¾	302¾	33½	9	14	10	18
19	10*	4¼*	11*	94*	28½*	32½*	10¾*	144*	...	33	0	40⅓	354½	39½	15	4	6	19
20	10†	...	...	...	...	...	...	...	...	25	0	38¾	354¾	39½	15	12	6	20

*Plot 19 got dung and artificials for 1894 and 1896, but nothing for 1895; in 1897 it got artificials, and 1398 dung, and so on in alternate years.

†Plot 20 got dung in 1894 and every alternate year thereafter.

NOTES. The standard dressing per acre for plot 14 is 8·75 lb. nitrogen, 50 lb. phosphoric acid, and 35 lb. potash; this has been supplied since 1900. [illegible] applied. Lime dust for plot 8 contained 230 lb. caustic lime. Plot 17 gets one-fifth and plot 18 one-tenth of

COUNTY DURHAM OLD LAND HAY EXPERIMENTS.

This is the first year (1902) of this set of experiments. The plan of manuring and the results are contained on Table VI., page 37. The plots are all duplicated at Tow Law, Bradbury, and Shincliffe, but are not so at Broomside House. At the latter centre the results are inconsistent in many cases probably because of variation in the soil, and these, therefore, should not be taken into account, at any rate, so far as this year is concerned.

CENTRES AND CHARACTER OF SOILS.

Centre.	Occupier.	Nature of soil.
Elm Park, Tow Low ...	Mr. J. Vickers ...	Strong loam on Boulder Clay overlying Coal Measures.
How Hills, Bradbury ...	Mr. H. G. Coates	Loam (wet haugh land with ditches) lying on Boulder Clay.
Shincliffe	Mr. J. Willan ...	Good alluvial soil on Alluvium.
Broomside House ...	Mr. T. Cleasby ...	Peaty loam lying on Boulder Clay.

Objects of experiments.—The principal objects are: (1) To ascertain the effects of omitting two of the three ingredients of a complete manure, and also of omitting one only of these ingredients; (2) to ascertain the effects of a half-dressing of artificials annually, and of a full dressing in alternate years only; (3) to compare the effects of artificials with dung, and with dung and artificials in alternate years; (4) to ascertain the effects of lime and of a heavy dressing of slag.

NOTES ON RESULTS.

The table of results shows the profit or loss for the first year, but as the unexhausted value of nearly all the manures is very much greater than the value exhausted last year, these figures must be made use of for comparison only.

Elm Park, Tow Law results.—Plots 4 and 6 show that a potash manure is not useful, in the first year at any rate, at this centre, and plot 5, where nitrogen and phosphates are applied, but potash is withheld, gives a very good crop, shewing that potash is not, so far, very effective on this strong loam soil or Boulder Clay. The complete artificials do well on plots 8 and 9 and the half dressing of these also do well on plots 10 and 11, but dung on plot 12 has not increased the crop in the first year. Generally the crop has responded exceedingly well in the first year at this centre to the various dressings of manures.

How Hills, Bradbury results.—This wet haugh land has been very little benefited by any of the dressings of manure in the first season. Even the nitrogenous manures (nitrate and sulph. am.) fail to give a profitable increase. This soil evidently does not give a quick response to manuring, and the results of future years must therefore be waited for before comparison of the different manurings can be made.

Shincliffe results.—This alluvial soil does not yet show great effects from the manures, although it is more responsive than that at How Hills. The nitrogenous manures give a profitable crop increase and a small profit is given by a few of the other dressings. Here the heaviest crops result from the complete artificials applied to plots 8 and 9. This land does much better under tillage than under pasture. It may be suffering from an alluvial deposit from lead workings farther up the valley.

Broomside House results.—For the reason already stated these must be disregarded. Attention is drawn, however, to the marvellous effect of 4 tons of lime per acre on this peaty loam soil, as it has produced over 2 tons hay per acre in the first season after the application of lime, an increase of 13½ cwt. of hay per acre over the unmanured plot.

TABLE VI.—FIRST YEAR OF CO. DURHAM HAY (OLD LAND) EXPERMENTS, 1902.

PLOTS $\frac{1}{20}$-ACRE. FIGURES PER ACRE.

Average of two plots.	Manures, 1902.						Cost of manures.	Yield of hay.												Average of two plots.
								Elm Park, Tow Law.			How Hills, Bradbury.			Shincliffe.			Broomside House (1).			
	Dung.	Nitrate.	Sul. am.	Super.	Slag.	Kainit.		1902.	Increase over unmanured plot.	Profit or loss (-).	1902.	Increase over unmanured plot.	Profit or loss (-).	1902.	Increase over unmanured plot.	Profit or loss (-).	1902.	Increase over unmanured plot.	Profit or loss (-).	
	ton.	lb.	lb.	lb.	lb.	lb.	s. d.	cwt.	cwt.	s. d.	cwt.	cwt.	s. d.	cwt.	cwt.	s. d.	cwt.	cwt.	s. d.	
1, 16	...	...	...	...	...	...	...	19½	...	...	27¼	...	...	27¾	..	...	27	...	...	1, 16
2, 17	...	54½	54	...	...	...	10 0	24½	5	2 6	29½	2¼	- 4 5	33	5¼	3 1	27	0	-10 0	2, 17
3, 18	...	...	...	164	142	...	7 1	24¼	4¾	4 9	28¼	1	- 4 7	30¾	3	0 5	29	2	- 2 1	3, 18
4, 13	...	...	...	...	...	412	8 5	21½	2	- 3 5	28¼	1	- 5 11	29	1¼	- 5 4	35¼	8¼	12 2	4, 13
5, 14	...	54½	54	164	142	...	17 1	33¾	14¼	18 6	30½	3¼	- 9 0	35	7¼	1 0	36½	9½	6 8	5, 14
6, 15	...	54½	54	...	...	412	18 5	27	7½	0 4	30¼	3	-10 11	36½	8¾	3 5	26½	- ½	-19 8	6, 15
7, 22	...	...	...	164	142	412	15 6	26¼	6¾	1 4	26¼	-1	-18 0	30	2¼	- 9 11	35¾	8¾	6 4	7, 22
8, 23	...	54½	54	164	142	412	25 6	35	15½	13 3	29¾	2½	-19 3	37	9¼	- 2 5	45	18	19 6	8, 23
9, 24	...	54½*	54*	164*	142*	412*	25 6	34½	15	12 0	31¼	4	-15 6	37¾	10	- 0 6	32¾	5¾	-11 2	9, 24
10, 19	...	27¼	27	82	71	206	12 9	27½	8	7 3	26¼	-1	-15 3	30	2¼	- 7 2	22¾	-4¼	-23 4	10, 19
11, 20	10†	27¼†	27†	82†	71†	206†	12 9	28¾	9¼	10 4	26½	-0¾	-14 7	30½	2¾	- 5 11	32¼	5¼	0 4	11, 20
12, 21	10‡	...	...	...	...	...	50 0	18¼	-1¼	-53 1	21¼	-6	-65 0	29	1¼	-46 11	36½	9½	-26 8	12, 21
S.	Plot	A: 4	tons	lime	...	...	50 0	...	.	...	...	...	...	...	...	...	40½	13½	-16 3	S.
S.	Plot	B: ½	ton	slag.	...	...	22 6	...	...	...	...	...	...	...	...	...	32½	5½	- 8 9	S.

Standard dressing: 20 lb. nitrogen (8·75 lb. in nitrate and 11·25 lb. in sul. am.); 50 lb. phosphoric acid (25 lb. in Slag and 25 lb. in Super.); and 50 lb potash (all in Kainit).

* Plots 9 and 24 got artificials in 1902, and in alternate years thereafter.

† Plots 11 and 20 got artificials only 1902; dung only 1903; and so on in alternate years.

‡ Plots 12 and 21 got dung in 1902; and in alternate years thereafter.

S These plots are each 1-5th acre in area and will not be manured again for some time.

(1) The plots at Broomside House are not duplicated as at other centres, and the soil at this centre is obviously uneven in character.

OLD LAND HAY EXPERIMENT AT EARL'S HOUSE, COUNTY DURHAM.

This commences with 1902, and is made on the Durham County Council's farm at Earl's House. The soil is a loam on Boulder Clay, which overlies the Coal Measures. The following table gives the plan of manuring and the results for the past season:—

TABLE VII.—FIRST YEAR OF OLD LAND HAY EXPERIMENT AT EARL'S HOUSE, CO. DURHAM.

PLOT ¼-ACRE IN AREA. FIGURES PER ACRE.

Plot.	* Manures, 1902.	Cost of manure.	Yield of Hay.	Increase over unmanured plot.
		s d.	Cwt.	Cwt.
1	No manure	...	28¼	...
2	20 tons dung	100 0	39½	11¼
3	392 lb. kainit	7 11	25¼	-3
4	½ ton slag + 392 lb. kainit	30 5	33½	5¼
5	½ ton slag	22 6	31½	3¼
6	2½ tons common lime	57 6	28¼	0

* No further manures are applied for 1903, but kainit only may be repeated for 1904.

These are all heavy dressings, which, where suitable, will continue to act for several years. Kainit has a deleterious effect in the first year and common lime has no influence on the yield. Slag increases the crop in the first year and kainit added to slag also does so, although its action is otherwise when applied alone.

Seeds Mixtures for Hay and Pasture at Whitehall, Cumberland.

This experiment was commenced in the spring of 1896, on a field kindly placed at the disposal of the College by Mr. Parkin Moore.

The objects of the experiment are:—To ascertain the value of different mixtures of grasses and clovers for two years' hay; and for the pasture thereafter.

Soil and climate.—The soil is a strong loam lying on a subsoil of Boulder Clay. The land was in good "heart" and in fairly clean condition when the seeds were sown, the previous crop having been roots eaten on the field by sheep. The field is about 330 feet above sea level, and the climatic conditions are favourable to the formation of a pasture, being those of the west coast generally, *i.e.*, a fair amount of rainfall throughout the year, and a milder winter and spring than there is further inland or near the east coast.

Eight plots, each ½ acre in area, were sown with different mixtures of seeds in April, 1896, along with a few pounds of rape seed per acre. The plots were, therefore, sown down without a crop and were eaten off by sheep in the first season. Full reports on the character of the different seeds mixtures and on the hay crops of 1897 and 1898 are contained in the fifth, sixth and seventh College Reports, and are summarized on Table VIII., page 40.

TABLE VIII.—SEEDS MIXTURES SOWN AT WHITEHALL, 1896, AND YIELD OF HAY, 1897 AND 1898.

	Cost per lb.	Plots.							
		1	2	3	4	5	6	7	8
	s. d.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
†Perennial ryegrass ..	0 2½	32·7	18·7	9·3	14·0	14·0	...	...	9·3
*Cocksfoot	0 11	...	3·7	4·9	7·4	3·7	3·7	4·9	4·9
*Timothy	0 5½	...	1·2	2·3	3·5	1·7	1·7	2·3	3·1
*Foxtail	1 9	...	...	...	...	3·8	3·8	5·1	...
*Meadow fescue ...	0 9	...	...	...	...	4·9	4·9	6·5	13·0
*Tall fescue	1 2	..	...	...	...	4·8	4·8	6·4	...
†Hard fescue	0 8	...	...	...	...	...	1·4	1·9	...
†Crested dogstail ...	1 4	...	...	...	...	...	0·9	1·3	...
†Smooth-stalked meadow grass	0 9	...	...	...	...	...	0·5	0·6	...
†Rough-stalked meadow grass	1 2	...	...	...	...	...	0·3	0·5	0·9
Cowgrass clover ...	0 10	4·7	4·7	4·7	7·0	7·0	7·0	9·4	2·3
Alsike clover	0 9	1·4	1·4	1·4	2·1	2·1	2·1	2·8	2·1
White clover	1 0	1·4	1·4	1·4	2·1	2·1	2·1	2·8	5·6
Yarrow	3 4	...	...	...	...	...	...	...	0·3
Total number of lb. per acre		40·2	31·1	24·0	36·1	44·1	33·2	44·5	41·5
Millions of germinating seeds per acre		10	10	10	15	15	15	20	20
Cost per acre :—		13/2	14/2	13/11	20/10	32/8	32/8	43/7	28 1
Yield of hay per acre :—		Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
1897		41½	37	44	47½	46¼	37½	37¾	47¼
1898		39	33	35½	33	36½	30	39½	44
Average		40¼	35	39¾	40¼	41½	33¾	38½	45¼

* Top grasses. † Bottom grasses.

The grasses on this table are classified into "top" and "bottom" grasses, the former being the more vigorous and producing more stems than root leaves, while the latter have a less vigorous habit of growth, and on the whole produce more root leaves than stems.

Plot 1 had perennial ryegrass and clovers only; on plot 2 30 per cent. less ryegrass was sown, but this was made up by adding cocksfoot and timothy; plot 3 had still less ryegrass (½ of plot 2), while cocksfoot and timothy were proportionately increased; plot 4 had the same seeding as plot 3, but the quantity was increased by half; plot 5 had as heavy a seeding as plot 4, but three other grasses—foxtail, meadow fescue, and tall fescue—were added, to make room for which the cocksfoot and timothy were reduced by one-half; on plot 6 ryegrass was entirely omitted—its place being taken by hard fescue, dogstail, smooth and rough stalked meadow grass, otherwise the seeding was similar to plot 5; plot 7 had the same plants as plot 6, but the amount of seed was increased by one-third; and plot 8 had the same number of germinating seeds as plot 7, but foxtail, tall fescue, hard fescue, dogstail, and smooth stalked meadow grass were withheld, and their places taken by perennial ryegrass and yarrow, while white clover was considerably increased and the other clovers decreased.

The cost of the seeds mixtures (per acre) is given on Table VIII. The first three were considerably the cheapest, that on plot 7 was the most expensive, while that on plot 8 was very much cheaper, although it contained as many germinating seeds as the one on plot 7; many of the more expensive seeds were excluded from plot 8.

The germinating power of all the seeds was tested at the College, and the calculated number of millions of germinating seeds sown on the plots is given on Table VIII.

The yield of hay for 1897 and 1898 is also given on Table VIII. The smallest average crop was given on plot 6;

on plot 7, where the same seeding was increased by one-third, the crop was still the third smallest. It is important to note when comparing plots 7 and 8—the latter grew the heavier crops of hay—smooth-stalked meadow grass, dogstail, hard fescue, tall fescue and foxtail were omitted from the latter plot, but a small seeding of perennial ryegrass was added, as well as some yarrow, while meadow fescue was doubled and white clover was increased at the expense of the other clovers, especially cowgrass. Ryegrass and clover only (plot 1) gave the same yield of hay as on plot 3, where cocksfoot and timothy largely took the place of the ryegrass, although when these did so to a smaller extent, the yield of hay was smaller. The yield of hay on plot 4 was not greater than on plot 3, although the same seeding was increased by 50 per cent. The seeds mixture on plot 8 was, therefore, the most useful in producing a hay crop.

Condition of pasture as indicated by plants present in 1902.—The plots have been grazed since 1899, but small portions of each were fenced off in 1902, so that the herbage could be sampled and analysed. The sampling was carefully done by Mr. Lawrence on July 4th, and a botanical analysis of the herbage of each plot has been made at the College. The results of this analysis, as well as the percentage of germinating seeds in each mixture, are given on Table IX., page 43. The number of seeds per lb varies very widely, and it is, therefore, most important to consider the percentage of germinating seeds sown on each plot (and not the weight of seeds) along with the percentage of plants now present in the herbage. The percentage of plants now present is given by weight and not by number. The time of the year (July 4th) must also be taken into account in considering these figures. The earlier grasses, such as foxtail and sweet vernal, are considerably past their greatest weight and luxuriance by this time, while a late grass like timothy would not yet have reached its greatest weight. At this time also Yorkshire fog is at about its most bulky state. If this is allowed for, however, in considering the results, very useful lessons can be derived from the figures.

TABLE IX.—WHITEHALL SEEDS MIXTURES FOR HAY AND PASTURE.

PERCENTAGE OF BOTANICAL COMPOSITION OF HERBAGE, 1902.

(Percentage in seeds mixtures of plants sown in 1896 is given in brackets underneath those of the above.)

	Plots.							
	1	2	3	4	5	6	7	8
Perennial ryegrass	21·2 (70)	15·3 (40)	13·8 (20)	10·2 (20)	7·7 (20)	0·8	2·6	12·4 (10)
Cocksfoot	5·4	14·3 (15)	18·1 (20)	25·8 (20)	25·8 (10)	42·2 (10)	48·2 (10)	40·1 (10)
Timothy	3·2	15·0 (15)	19·4 (30)	15·8 (30)	11·6 (15)	1·9 (15)	7·4 (15)	5·1 (20)
Foxtail...	...	...	...	...	4 (10)	2 (10)	6 (10)	...
Fescues...	1·8	2·0	...	1·2	17·3 (15)	15·8 (20)	15·0 (20)	7·7 (15)
Crested dogstail	13·9	10·0	14·8	10·9	20·6	23·8 (5)	5·5 (5)	9·1
Oat grasses	1·2	...	...	...	0·4	...	...	...
Bent grasses (agrostis sp.) ...	22·1	23·3	18·6	14·9	2·6	5·1	12·4	6·7
Yorkshire fog	26·7	17·4	9·6	15·6	4·3	6·1	1·0	3·0
Clovers	1·7 (30)	0·9 (30)	4·5 (30)	4·7 (30)	4·1 (30)	1·3 (30)	1·4 (30)	7·4 (30)
Yarrow...	...	...	...	...	...	...	...	5·6 (5)
Weeds, seeds, dirt, etc. ...	2·8	1·8	1·1	0·9	1·6	1·0	0·5	2·9
Total	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

Results of botanical analysis.—When Mr. Lawrence collected the samples for analysis he also made the following notes on the appearance of the pasture and hay on the plots on July 4th:—

> "Plot 1.—Mainly dogstail and Yorkshire fog, weedy, very little clover. Grazed badly, and inferiority very marked.

"Plot 2.—Some clover and ryegrass; more cocksfoot, tall fescue, dogstail, timothy and trefoil, and still more Yorkshire fog. Thin pasture.

"Plot 3.—Yorkshire fog abundant, with a fair amount of cocksfoot, timothy and tall fescue. Fairly heavy hay with some red clover and trefoil. Pasture poor and benty, with thistles, but a fair white clover plant.

"Plot 4.—Similar to plot 3.

"Plot 5.—Some ryegrass; more cocksfoot, timothy, tall fescue and dogstail; much less Yorkshire fog; a fair hay crop. Pasture has a poor bottom and is somewhat benty.

"Plot 6.—Strong tall fescue and cocksfoot, some timothy. Pasture grazed bare, with bents of fescue and dogstail only; a fair plant of white clover.

"Plot 7.—Heaviest hay crop; mainly cocksfoot and tall and meadow fescue, with a little timothy and some white clover. Stems of dogstail abundant on pasture, but all other grasses closely grazed.

"Plot 8.—Good hay crop of luxuriant white clover, with cocksfoot and dogstail, and a fair quantity of timothy and meadow fescue; a little Yorkshire fog, ryegrass and red clover, but no rough-stalked meadow grass. *Best grazed pasture*, with very little bent and a good sole of white clover—*an excellent plot*."

These notes, describing as they do the appearance of the pasture on the different plots as well as the hay on the portions of the plots fenced off for the purpose, are of great assistance in discussing the results.

Perennial ryegrass has not proved to be a good lasting plant for a pasture. Plots 1 and 2, which have the largest proportion of this grass, are now the thinnest pastures. Table IX. shows that on all the plots, except plot 8, the proportion of this grass now growing is very much less than the proportion sown. The small amount of this grass now on plots 6 and 7, where none was sown, indicate its small powers of establishing itself naturally on this land.

Cocksfoot is now present in very much greater proportion than it was sown in, except where sown with the larger amounts of ryegrass (plots 2 and 3). The results indicate that ryegrass sown with this grass, tends to check its development, and this takes place in the earlier years, before the ryegrass loses its vigour. There is a very large proportion (over 40 per cent.) of this grass now present on plots 7 and 8 and yet both these plots are reported as being closely grazed, thus showing that this grass gives neither a coarse nor a benty pasture. On plot 1 where no cocksfoot was sown it has developed naturally to a very small extent.

Timothy. This grass, unlike cocksfoot, has developed better when sown with, than without, ryegrass. Timothy has a very small plant for a considerable time after being sown, and it may be that the protection given by the quick-growing ryegrass is an advantage to it during the first season, or even two seasons, after sowing. There is not much timothy on plot 1 where none was sown, and where this grass was included the proportion now growing is considerably less than that sown (except on plot 2).

Meadow foxtail is present in moderate quantities where sown, but has not developed naturally on the other plots. This grass, however, is very luxuriant in May and early June, and is not nearly so abundant in July when the samples were taken.

The fescues are grouped together in Table IX. Tall fescue is most abundant on plots 5, 6 and 7 where this grass was sown and greatly increases the proportion of fescues on these plots. There is not much hard fescue where sown on plots 6 and 7. On plot 8, where meadow fescue only was sown and is practically the only species of fescue present, the stems of this grass are much finer than those of tall fescue The strong, tall fescue, as well as meadow fescue, are closely grazed on all the plots where they were sown and do not form bents or withered stems, left uneaten by the grazing stock Where no fescues were sown they are present only to a very small extent.

Crested dogstail was sown in very small proportion o plots 6 and 7, but is present on all the plots to a large extent The stems of this grass are not eaten by grazing stock, and so remain to form the bents noticed by Mr. Lawrence especially on plot 6 where this grass forms about 24 per cent. of the herbage. These stems are, therefore, allowed to produce seed and thus encourage the development of this grass to the exclusion of better plants more relished by stock.

The meadow grasses (smooth-stalked and rough-stalked) are not present in the herbage of plots 6 and 7 where they were sown, nor were they noticed by Mr. Lawrence.

The clovers are now present in comparatively small quantities although 30 per cent. of these were sown on all the plots. There is some red clover now but no alsike, and probably the former is natural wild clover. White clover, however, is present on all the plots in fair quantity, and on plot 8, where the proportion of seed sown was four times greater than on most of the other plots, this plant is luxuriant and abundant, especially on the pasture. The proportion shown by the botanical analysis does not indicate the full amount of this plant because its creeping habit of growth keeps it largely in the bottom herbage.

Yarrow has proved a useful plant on plot 8 and is present in about the same proportion as when sown.

Yorkshire fog proves to be most troublesome by far where ryegrass only was sown on plot 1. Here it constitutes over one-fourth of the herbage. The thin bottom left when the ryegrass began to fail, has evidently given the opportunity for this pernicious grass. On plots 7 and 8, where close bottoms of herbage have been formed, this grass is present in very small quantities, thus indicating that it may be held in check by covering the ground with suitable pasture plants.

The bent grasses, or various species of *Agrostis*, have also been allowed to develop to the greatest extent on plots 1 and 2 where the largest amounts of ryegrass were sown. These grasses are even more troublesome to the farmer than Yorkshire fog, the common bent being well-known as surface couch because of its stems creeping along the surface of the ground. On plots 4-8 these plants have been fairly effectually held in check.

The best plot.—The heaviest yield of hay in the first two years (1897 and 1898), and the excellent condition of the pasture in 1902 on plot 8, when taken together indicate that the meadow grasses and crested dogstail have not been useful, that the four grasses—perennial ryegrass, cocksfoot, timothy and meadow fescue—have made a very good combination in the proportions sown, that the larger proportion of white clover than of the other clovers has been advantageous both to the hay and the pasture, and that the heavier seeding of 20 million germinating seeds has given good results. Although cocksfoot is now present to the extent of 40 per cent. on this plot, it is closely grazed and is not at all coarse. The sowing of a small amount of yarrow on this plot has probably also been useful. Probably also the increased amount of meadow fescue and the exclusion of tall fescue has assisted to the good result on this plot. Rough-stalked meadow grass has probably not been useful on this plot, and, as the seed of this cost 1s. 0½d. per acre, the cost of this seeds mixture might have been reduced to 27s. 10d. an acre, while if yarrow were omitted the cost would be still further reduced to 26s. 9d. an acre.

These results will not, of course, apply to all conditions of soil and climate, but where these conditions are both somewhat like those prevailing at Whitehall, the seeds mixture sown on plot 8 should prove a successful one.

The portions of the plots fenced off for mowing in 1902 had all been grazed in the previous years, so that the various plants found in the herbage are those developed by grazing. Had the plots been mown every year and not grazed, the plants present would have been those developed by growing hay instead of pasture. A considerable amount of bottom herbage is not removed by mowing, but the character of this is stated in Mr. Lawrence's notes.

It is of the greatest importance, in purchasing grass and clover seeds, to insist that the percentage of purity, and the germinating percentage, as well as the number of germinating seeds in a pound, shall be stated on the invoice, and to arrange that the different seeds be forwarded separately. The greatest care must, of course, be taken in mixing the seeds and in sowing them. The prices given on Table VIII. were those of the spring of 1896, and are, on the average, approximate to those of the present spring.

EXPERIMENT ON THE IMPROVEMENT OF ROUGH PASTURE AT PIKE WHINS.

This experiment is being made on the farm of Pike Whins. County Durham, on land kindly placed at the disposal of the College by Mr. Anthony Wilkinson, J.P., D.L. The farm adjoins Hurworth Burn station, extends to about 200 acres, and is all under rough pasture. It is laid up in narrow ridges, but has probably not been under cultivation since the early years of the nineteenth century. The land has become very rough and uneven, and the greater part of it is covered with heather and some whins; as a pasture it is not worth more than a few shillings an acre. The improvement of this land has been undertaken in a thorough manner. It is all being drained with parallel drains about 42 feet apart; a considerable part of it has been treated with basic slag, and a smaller part with kainit in addition. Part has also been limed, and other parts are being sown with renovating seeds mixtures, heavy-toothed chain harrows being used to cover in the seeds, as well as to render the surface more even, and to remove some of the heather stems. The heather has been burned on the parts where it was present in greatest amount.

The soil varies from a sandy loam to a clay loam, and is rather shallow in some parts but deeper in others. The surface soil is moorish in character—dark in colour, and rich in organic matter. The subsoil is a yellow to reddish sand mixed with clay, boulders of limestone and other stones, and gravel. It lies on Boulder Clay of a sandy character, and the presence of gravel in addition to boulders of stone gives it quite a different character from stiff Boulder Clay, such as that at Cockle Park. As an indication of the freeness of the subsoil it may be stated that the drains now being put in 4 feet deep and over 40 feet apart are doing their work effectively. The land on which the experimental plots are laid off is very rough and heathery, and represents the heavier land of the farm.

The objects of the experiments are:—(1) To ascertain the effects of different manures in improving this land; (2) to test the usefulness or otherwise of renovating seeds mixtures.

Effects of different manures.—13 plots each $\frac{1}{20}$ acre in area, have been laid off. The plan which follows shows the relative position of the plots and the manuring per acre:—

N

Plot 1. 2½ cwt. slag (annually)	Plot 2. 3¾ cwt. kainit (annually)	Plot 3. 2½ cwt. slag, 3¾ cwt. kainit (annually)
Plot 4. 3½ cwt. super., 3¾ cwt. kainit (annually)	Plot 5.* ½ cwt. sulph am.. ½ cwt. nitrate, 2½ cwt. slag, 3¾ cwt. kainit (annually)	Plot 6. Half the dressing of plot 5 (annually)
Plot 7. 10 tons dung 1902, and in alternate years	Plot 8. No manure	Plot 9. 10 cwt. slag (10 tons dung 1905)
Plot 10. 10 cwt. slag, 3¾ cwt. kainit	Plot 11. 10 cwt. slag (artificials of plot 6, 1905 and annually thereafter).	Plot 12. 10 cwt. slag and 4 tons lime
		Plot 13. 4 tons lime

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* Plot 5 receives standard dressing of 20 lb. nitrogen (8·75 lb. in nitrate and 11·25 lb. in sulph. am.); 50 lb. phosphoric acid (all in slag); and 50 lb. potash (all in kainit).

All the manures were applied for the first time early in 1902. The manures have had very little effect during this season. · Farmyard manure has been most successful in starting a growth of herbage among the heather roots, and, of the artificial manures, slag and kainit combined have been most effective, but the effects of any of these are as yet not marked. On other parts of the farm slag applied a year earlier than the manures on the experimental plots is already promising to be effective, and is encouraging the growth of white clover, while kainit applied at the same time promises to be even more useful for this purpose.

Renovating seeds mixtures.—Three plots, each 1 acre in area were sown in the late summer of 1902, with the following renovating seeds mixtures. The plots have been dressed previously with 10 cwt. basic slag per acre and the seeds were harrowed in with toothed chain harrows.

Mixtures of seeds sown:—

Plot A: 6 ℔ white clover, ½ ℔ cowgrass clover, ½ ℔ alsike, ¾ ℔ smooth-stalked and ½ ℔ rough-stalked meadow grass, ½ ℔ crested dogstail, 1 ℔ hard fescue, 1 ℔ timothy, 1 ℔ cocksfoot, and ¼ ℔ golden oat grass; containing 9¾ millions seeds and costing 11s. an acre.

Plot B: 9 ℔ white clover and 3 ℔ timothy, containing 10½ millions seeds and costing 9s. 2d. an acre.

Plot C: 12 ℔ white clover, containing 8½ millions seeds and costing 10s. 2d. an acre.

The clovers are taking fairly well, especially on the barer parts, and some of the grasses have also made a start.

Rotation Experiments.

Rotation experiments have been in progress at Peepy and Whitefield since 1894; also at Rose Bank, Dalston, and Kimblesworth, Chester-le-Street, since 1896. The complete results of these experiments for former years are contained in earlier reports, but the present report contains in each case a very short summary of them. The results of these rotation experiments give lessons of a far more valuable character than those with roots, etc., which are made for one year only. They are therefore well worthy of study by those desirous of obtaining information as to the manuring of their arable land throughout a series of crops. The nature of the soil at the different centres must be carefully taken into account in comparing the results.

ROTATION EXPERIMENTS AT PEEPY AND WHITEFIELD.

These experiments have been in progress for nine years on the farms of Mr. J. Knox Lyal, at Peepy, Stocksfield-on-Tyne, and of Mr. John Angus, Whitefield, Morpeth. The swede crop for 1902 is the first crop of the third four-course rotation. The crops of each rotation are (1) swedes, (2) barley, (3) seeds hay, and (4) oats.

The objects of the experiments (third rotation) are:— To compare the effects of dung only with dung and different dressings of artificials; to show the effects of varying amounts of dung with artificials; to ascertain the effects of artificials only; to compare the more important phosphatic manures, and a complex mixture of these in different dressings of artificials; to ascertain the effects of a double dressing of artificials, and also of omitting the potash manure; and to compare the effects of applying either dung or artificials all to the root crop, or the withholding of part of these for direct application to the remaining crops. Horse dung and corporation manure are also tested on special plots.

Soils.—The soil at Peepy is a sandy loam, which becomes a clay loam at the bottom of all the plots: it is probably derived principally from the Millstone Grit formation, with some Boulder Clay at the lower end of the field. The soil at Whitefield is a fertile, sandy loam, with a gravelly, red sandstone subsoil, lying on the Glacial Sands and Gravels.

The soils at both these centres were in a high state of cultivation—as a result of liberal farming and careful tillage—when the experiments were commenced in 1894, and were selected as being typical of well-farmed land in Northumberland, and not, as in the case of the County Farm at Cockle Park, because of the poor and exhausted state of the soil.

Plan of manuring.—The plan of manuring for the first and second rotations is summarized on page 52 of the Tenth Annual College Report (1901), and the plan of manuring for the third rotation will be found on Table X. (page 58) of this report.

RESULTS OF FIRST TWO FOUR-COURSE ROTATIONS.

These are contained in previous reports and are fully summarized in the report for 1901. The plan of manuring for the first two rotations was different on some of the plots to that of the third.

The most striking results were:—

1. The lighter soil at Whitefield has been more susceptible to good or bad treatment than the heavier soil at Peepy, which latter responds more slowly to manuring, and suffers less quickly from the want of it. The unmanured plot deteriorated to the greatest extent during the first rotation at Whitefield, but at Peepy during the second. Apart from their different rate of action the effects of the various phosphatic manures have been very similar at both farms.
2. Dung gave good returns at both centres, but small dressings were more profitable than large.
3. Artificials added to dung have not greatly increased the root crops, but on the whole have been profitable, when the remaining crops of the rotation are taken into account.

Results with swedes, 1902.—First year of third rotation:—There are 20 plots at each centre, each being ¼ acre in area. The manuring for the third rotation and the results with swedes for 1902 are given on Table X. (page 58). The hay crop of 1904 will also receive a dressing of ½ cwt. nitrate per acre on all the plots. All the manures have been applied for the swede crop of 1902 except where otherwise stated. Best of All swede was grown at Whitefield and Champion swede at Peepy.

Notes on Results with Swedes, 1902.

Plots 1-9 have dung and artificials.—The dressing of artificials per acre was approximately ⅜ cwt. sulph. am., ½ cwt. bone meal, ¾ cwt. dissolved bones, ½ cwt. fish meal, ⅝ cwt. super., ½ cwt. slag, and 2 cwt. kainit. The results on these plots are as follows:—

Plot.	Manuring.	Tons of Swedes per acre.	
		Peepy.	Whitefield.
1	12 tons dung	20¼	20½
2	12 tons dung + artificials	22½	24½
3	12 tons dung + double artificials	23½	25½
4	12 tons dung + artificials (but sulph. am., fish meal, and kainit kept for hay, 1904) ...	22¼	24
5	6 tons dung + artificials (6 tons dung for hay, 1904)	22½	24½
6	6 tons dung + artificials	21½	23¾
7	9 tons dung + artificials	22¼	24
8	15 tons dung + artificials	22¾	26¼
9	12 tons dung + half artificials	22½	25¼
10	No manure	13½	11¾

The Peepy results show:—On plots 1 and 10 that 12 tons of dung increase the crop by nearly 7 tons; on plots 1 and 2 that artificials added to dung increase the swede crop by over 2 tons; on plots 2, 3 and 9, that a half dressing of artificials with dung does as well for swedes as a full dressing, and that a double dressing does not give much increase; on plots 2, 5, 7 and 8, that 6 tons of dung give practically as good a crop as 9, 12 and 15 tons; and that all the manured plots give large increases over plot 10, the unmanured plot.

The Whitefield results show:—On plots 1 and 10 that 12 tons of dung increase the crop by nearly 9 tons; on plots 1 and 2 that artificials added to dung increase the crop by 4 tons; on plots 2, 3 and 9, that a half dressing of artificials with dung is practically as good as a full or a double dressing; on plots 5, 7, 2 and 8, that 6 tons of dung do as well as 9 and 12 tons, but 15 tons of dung do rather better; and that the manures in most cases more than double the crop.

Plots 11-18 have artificials only.—The standard dressing of artificials per acre contains 35 ℔ nitrogen, 100 ℔ phosphoric acid, and 50 ℔ potash. Plots 11-15 receive this standard dressing. On the dung plots the normal application of artificials is equivalent to half the standard dressing. These tables show the manuring to the nearest ⅛ of a cwt.

Plot.	Manuring.	Tons of Swedes per acre.	
		Peepy.	Whitefield.
10	No manure	13½	11¾
10a	No manure (12 tons dung 1898)	15½	15
11	¾ cwt. sulph. am., 3¾ cwt. bone meal, 3¾ cwt. kainit	18½	21¼
12	¾ cwt. sulph. am., 5⅞ cwt. diss. bones, 3¾ cwt. kainit	20½	22¼
13	¾ cwt. sulph. am., 5⅛ cwt. super., 1¾ cwt. fish meal, 3¾ cwt. kainit	21¾	23½
14	¾ cwt. sulph. am., 4½ cwt. slag, 1¾ cwt. fish meal, 3¾ cwt. kainit	21½	23½
15	Same artificials as plot 3, containing ¼ of total dressings applied to plots 11-14	21¼	22½
16	Same artificials as plot 15, but no kainit ...	15	19¼
17	Double artificials of plot 13	21¾	25½
18	Same artificials as plot 13, and ⅓ of this for each of next three crops	20¼	25¾

The Peepy results show:—On plots 11 to 15, that of the phosphatic manures super. gives the best result, that slag is nearly as good, and that dissolved bones, and especially bone meal, are not so effective, nor is the more complicated dressing on plot 15 quite so effective as the simpler dressings on plots 13 and 14; on plots 15 and 16, that the omission of the potash manure reduces the crop by 6¼ tons; on plots 13 and 17, that a double dressing of artificials does not increase the crop; and on plots 10 and 13 that artificials only increase the crop by over 8 tons.

The Whitefield results show:—On plots 11 to 15, that slag and super. do equally well, and better than diss. bones or bone meal or the mixture of phosphatic manures on plot 15; on plots 15 and 16, that when potash is withheld the crop is decreased by over 3 tons; on plots 13 and 17, that the double dressing of artificials has increased the crop by 2 tons, but at the same time plot 18 has done as well as plot 17; and on plots 10 and 13 that artificials alone increase the crop by nearly 12 tons.

Plots 19 and 20 have special dressings.—These plots are manured differently at Peepy and at Whitefield. The manures applied for the swedes and the results at Peepy and at Whitefield are as follows:—

Plot.	Manure per acre.	Tons of Swedes per acre.
	PEEPY.	
19	12 tons horse dung	20
20	¾ cwt. sulph. am., 5⅛ cwt. super., 1¾ cwt. fish meal, 3¾ cwt. kainit (same as plot 13)	17¼
	WHITEFIELD.	
19	12 tons horse dung + 6 cwt. crushed bones	26½
20	24 tons corporation manure + 6 cwt. crushed bones ...	25¾

Horse dung and crushed bones do well at Whitefield and corporation manure and crushed bones do nearly as well. These plots were specially arranged to test the effects of applications of manures in common use locally.

It has already been stated that the plan of manuring for the third rotation differs materially from that of the first two. There is evidence from the results for 1902 that these are, to a certain extent, modified by the effects of previous manurings. This is notably the case in comparing plots 10 and 10a, as the latter plot gives 2 tons more swedes at Peepy and over 3 tons more at Whitefield than the former. This is evidently due to the "residue" of the 12 tons dung per acre applied to plot 10a in 1898.

The most striking result at both of these centres last year is the marked effect of the potash manure on the swede crop, this being especially so at Peepy. It is natural to expect that the soil at Peepy, mainly derived from the Millstone Grit, and that at Whitefield, lying on the Glacial Sands and Gravels, should respond well to potash manuring. Complete artificials only and dung only give very satisfactory crops of swedes, but dung and artificials in combination do not on the whole give effective results.

TABLE X.—PEEPY AND WHITEFIELD ROTATION EXPERIMENT.

THIRD COURSE (FIRST YEAR). PLOTS ¼-ACRE. FIGURES PER ACRE.

Plot.	Manuring for Swedes.								Manuring for subsequent crops, barley, hay,* oats.	Yield of Swedes, 1902.	
	Dung.	Sulph. Am	Bone Meal.	Dis. Bones.	Super.	Slag.	Fish Meal.	Kainit.		Peepy.	Whitefield.
	Tons.	lb.	b.	lb.	lb	lb.	lb.	lb.		Tons. cwt.	Tons. cwt.
1	12	...	...	...	...	...	...	...		20 6½	20 9½
2	12	44	52	82	72	63	50	202		22 10½	24 7¼
3	12	88	104	164	144	126	100	412		23 8½	25 10¼
4	12	...	52	82	72	63	...	...	† 44 lb. sulph. am., 50 lb. fish meal, and 206 lb. kainit for the hay.	22 5½	23 18¾
5	6	44	52	82	72	63	50	206	‡ 6 tons dung for the hay.	22 9½	24 8
6	6	44	52	82	72	63	50	206		21 11	23 18
7	9	44	52	82	72	63	50	206		22 4½	24 2¼
8	15	44	52	82	72	63	50	206		22 16	26 4
9	12	22	26	41	36	31½	25	103		22 8½	25 5
10	...	...	...	...	...	...	...	...		13 12	11 14¾
10A	...	...	...	...	...	...	...	...		15 9	15 0¾
11	...	89	416	...	...	...	...	412		18 13	21 7½
12	...	84	...	656	...	...	...	412		20 10½	22 4
13	...	89	...	...	576	...	200	412		21 14	23 12½
14	...	89	...	...	...	504	200	412		21 10	23 11½
15	...	88	104	164	144	126	100	412		21 6	22 12¾
16	...	88	104	164	144	126	100	...		14 18½	19 4¼
17	...	178	...	...	1152	...	400	824		21 13	25 11
18	...	89	...	...	576	...	200	412	§ 30 lb. sulph. am., 192 lb. super., 66 lb. fish meal, and 137 lb. kainit, for each of the subsequent crops.	20 7	25 13
19	Peepy—12 tons horse dung									20 0½	...
	Whitefield—12 tons horse dung, and 6 cwt. crushed bones									...	26 12
20	Peepy—Artificials of plot 13									17 6	...
	Whitefield—24 tons Corporation manure and 6 cwt. crushed bones									...	25 14

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* In addition to the manures shown in the table, all the plots get about ½ cwt. nitrate (8·75 lb. nitrogen) for the hay crop.

ROTATION EXPERIMENT AT ROSE BANK, DALSTON.

This is being made at Rose Bank, Dalston, by Mr. R. Tinniswood, who places 6 acres of land at the disposal of the College for this purpose. On this land twenty-four ¼ acre plots are laid off. A first five years' rotation has been completed and the first two crops of a second five years' rotation have been removed.

The objects of the experiment are:—To compare the effects of applying artificials to the roots only with spreading them over the crops of the rotation; to contrast the effects of slow and quick-acting artificial manures; to ascertain if potash manuring is profitable, either without or with dung; and to ascertain the effect on the subsequent crops of feeding linseed cake to sheep on the roots. The scheme for the second rotation also includes the ascertaining of the value of the "manurial residues" of the dressings applied during the first rotation to plots 19, 20 and 21. The dressings on plots 20 and 21 are practically the same, but plot 20 will receive dressings of nitrate for the hay and cereal crops of the second rotation to test the power of the nitrate to "extract" these residues. These all apply to the second rotation; they differ somewhat from those of the first.

The soil is a poor loam of medium texture, contains fragments of freestone, and represents the ordinary moorland of the district. There is a stiff, impervious "pan" characteristic of moorland, under a surface of 8 to 9 inches of soil. The land on which plots 1-18 are situated was broken up from poor old pasture (valued at 7s. 6d. an acre) about 1892, while that of plots 19-24 has been a few years longer under cultivation. This soil is very deficient in available phosphates and potash. An analysis is given on page 148 of the report for 1901. The soil is very uniform throughout.

Results of first rotation.--The crops were swedes, oats, hay, hay, and oats (1896-1900). Farmyard manure was not effective, probably because of the abundance of organic matter in this moorland soil. Dung added to artificials was very little more effective than artificials applied alone. Artificials alone without potash gave fair results, but the addition of potash (4 cwt. kainit) had excellent effects, especially on the last cereal crop. It was also found to be much more profitable to apply the artificials to the root crop only than to spread them over the crops of the rotation. The swede crop of 1896 was a failure on most of the plots; these conclusions, therefore, refer to the remaining crops of the rotation.

Second rotation of crops, 1901-5.—The course of cropping is swedes, oats, hay, hay, oats. The plan of manuring and the results for swedes, 1901, and oats, 1902, are given on Table XI., page 62. In 1901 the swedes on the unmanured plot weighed only 1¼ tons, whereas on all the manured plots the crop varied from just over 15 to nearly 22 tons. Nine tons dung gave an average of 17¼ tons swedes (plots 4, 6, 19, 20 and 21); artificials, without potash, added to 9 tons dung gave 18½ tons swedes (plots 22 and 23); a potash manure added to 9 tons dung gave no increase (plot 7); 15 tons dung increased the crop to 19⅝ tons (plots 12 and 14). Artificials only, without potash, gave over 19¼ tons swedes (plot 1), but the same, with the addition of 1 cwt. mur. potash, increased the crop to over 21¾ tons (plot 2), this being the best result of all the plots.

The oat crop of 1902 produced 32½ bushels of grain on the unmanured plot and from 37 to 69¼ bushels an acre on the manured plots. Artificials without potash to the roots have done better for the oats than artificials with potash (plots 1 and 2), an opposite result to the last oat crop of the first rotation; and a potash manure added to 9 tons dung has decreased the oat crop (plots 6 and 7); artificials alone have been much more useful for the oat crop than dung only (compare plot 1 with plots 4, 12, 21, etc.); and artificials all applied to roots are better for the first crop of oats than when they are spread over the rotation (compare plots 1 and 3, etc.).

The most striking results on the oat crop are the remarkable crops of grain given where 5 cwt. linseed cake were fed to sheep on the roots (plot 23), and a still better result is given where the "manurial equivalent" of the linseed cake is given direct to the oat crop in the form of fish meal and other manures (plot 24). The results of feeding off the roots by sheep are as follows:—

Plot.		Oats, bushels per acre.
1	Artificials to swedes, swedes not fed off	52
22	Do. do. ½ of swedes fed off by sheep getting 6 cwt. seeds hay...	57½
23	Do. do. ½ of swedes fed off by sheep getting 6 cwt. seeds hay and 5 cwt. linseed cake	66
24	Do. do. Fish meal, etc., for oats as manurial equivalent of 5 cwt. linseed cake, swedes not fed off	69½

These plots will be watched with interest for the remainder of the rotation.

It is very curious to note the non-effectiveness of potash on the first crop of oats of this rotation, and the success of the potash manure on the last oat crop of the former rotation.

Cereals and roots on an exhausted soil.—Prof. Middleton pointed out in last year's report how much better the oat

TABLE XI.—ROSE BANK ROTATION EXPERIMENT. SECOND COURSE. FIRST AND SECOND YEARS.

PLOTS ¼-ACRE. FIGURES PER ACRE.

Plot.	Manuring per acre for swedes.						Manuring for subsequent crops, oats, hay, hay, oats.	Yield of swedes, 1901.		Oats, 1902.	
	Dung.	Sulph. am.	Super.	Bone meal.	Dis. bones.	Muriate.				Yield of grain.	Yield of straw
	Tons.	lb.	lb.	lb.	lb.	lb.		Ton.	cwt	Bush. of 42 lb.	Cwt.
1	...	108	163	208	164	...	Nothing	19	7	52	31
2	...	108	163	208	164	103	Do.	21	16	47¾	29¼
3	..	72	109	139	109	69	One-sixth of dressing for plot 2 to first hay crop and last cereal crop	17	0	40¼	30
4	9	...	...	...	...	...	Nothing	18	6	40½	29
5	9	108	163	208	164	...	Do.	20	9	51¼	27
6	9	..	...	...	...	...	One fourth of standard dressing to each crop	17	11	48	31¼
7	9	...	...	...	...	51	Same as Plot 6, with 26 lb. additional muriate of potash to each hay crop	17	5	38¼	32
8*	9	45	...	208	...	...	205 lb. mixed super., diss. bones, and sulph. of am. to first hay crop and final cereal crop	18	15	37	24
9†	9	127	325	...	328	...	Nothing	21	15	45¼	34¼
10†	9	63	163	...	164	...	Same as Plot 8	20	0	41¼	28½
11	...	...	...	...	...	...	Nothing	1	5	32½	21¼
12	15	...	...	...	...	...	Do.	18	16	47½	31½
13	15	108	163	208	164	...	Do.	20	18	52¼	34
14	15	...	...	...	...	...	Same as Plot 6	19	9	49¼	33
15*	15	45	...	208	...	...	Same as Plot 8	19	4	50½	32½
16†	15	127	325	...	328	...	Nothing	20	9	52½	33½
17†	15	63	163	...	164	...	Same as Plot 8	17	19	49¼	30¼
18	15	...	...	...	...	51	Same as Plot 7	16	2	41½	27¾
19	9	...	...	...	...	...	Nothing	15	7	48¼	28½
20	9	...	...	...	...	...	84 lb. nitrate to each crop	17	11	63½	33½
21	9	...	...	...	...	...	Nothing	17	6	45	26½
22	9	108	163	208	164	...	Half of root crop fed off by sheep getting 6 cwt. seeds hay per acre	18	12	57½	30
23	9	108	163	208	164	...	Half of root crop fed off by sheep getting per acre 6 cwt. seeds hay and 5 cwt. linseed cake	18	7	66	35¼
24	9	108	163	208	164	...	151 lb. fish meal, 50 lb. sulph. of amm., 12½ lb. muriate to first corn crop only‡	19	14	69¼	40

NOTES.—The standard dressing (plot 1) contains 35 lb. nitrogen in sulph. of amm., bone meal and diss. bones; 100 lb. phosphoric acid (25 lb. soluble in super., 50 lb. in bone meal, and 25 lb. total phosphates in diss. bones. Plot 2 and the other plots receiving potash get 50 lb. as muriate.

*Plots 8 and 15 have half of standard dressing for swedes and remainder for hay and oats, all the bone meal going on the swedes.

†Plots 9, 10 16 and 17 get all phosphoric acid as super. and diss. bones.

‡Plot 24 receives fish meal, etc., containing manurial equivalent of 5 cwt. linseed cake fed on plot 23, after allowing for what is retained by animal.

crop could grow on the unmanured plot than the root crop. This is again very strikingly illustrated. The unmanured plot produced only 1¼ tons of swedes in 1901, but it has succeeded in producing 32½ bushels of oats in 1902. The available phosphoric acid and potash in the soil of this plot is in each case under ·01 per cent. From the results it is evident that the swede crop cannot succeed with these low amounts, but that the oats can make a very good struggle indeed, as they still produce a respectable crop on this plot.

Nitrate has so far succeeded remarkably well in "extracting" the residue of the heavy dresssing of artificials applied for the first rotation to plot 20 as well as the residue of the dung for swedes in 1901. The residues are practically the same on plot 20 and 21, but ¾ cwt. nitrate applied to plot 20 has given 63½ bushels of oats, whereas plot 21 has only given 45 bushels; being an increase, therefore, of 18½ bushels where nitrate was applied. Plots 19, 20 and 21 each received 12 tons dung and 14 cwt. artificials during the first rotation.

ROTATION EXPERIMENT AT KIMBLESWORTH.

This is being conducted at Kimblesworth, Chester-le-Street, by Mr. George Liddell. The first five years' rotation has been completed and a second five years' course has now been in progress for two years.

The objects of the experiment are:—To test light and heavy dressings of dung, with and without artificials; to compare the effects of applying artificials to roots only, with spreading them over the crops of the rotation; to compare various phosphatic manures as well as a mixture of these; and to ascertain which manurial ingredient is most wanted and also what is the most suitable amount of each ingredient.

The soil is a good, medium sandy loam lying on a rather sandy Glacial deposit and is clean and in good condition. An analysis of it is given on page 148 of the 10th College Report. It is rather poor in citric-acid-soluble phosphates and potash.

Results of first rotation.—The crops were potatoes, barley, hay (two years) and oats, grown in the years 1896-1900. There were 22 one-fifth acre plots. A heavy dressing of dung (18 tons) proved to be unusually profitable. Artificials alone gave very poor results, but when used with 12 tons of dung, some of the mixtures were profitable, the best being 1⅛ cwt. sulph. am., 5 cwt. super. and 5 cwt. kainit. Super. was the best of the phosphatic manures, and complex dressings were not the most profitable. There was no advantage from spreading the artificials over the rotation nor from topdressings of suplh. am. to the hay and oat crops. It should be noted that the first crop of this rotation was potatoes and not swedes.

Second rotation of crops, 1901-5.—Plots 1-4 are not continued for this rotation, as the soil of these plots is not quite uniform. There are now, therefore, 18 plots, each ⅛ acre in area, numbered 5-22. The course of cropping is swedes (not potatoes), barley, oats, and hay (two years). The plan of manuring and the results for swedes, 1901, and oats, 1902, are given on Table XII. (page 66). The swede crop was a good one, and varied on the manured plots from 17⅛ to 22¼ tons, while on the unmanured plot the crop was only 28 cwt. The yield of swedes on plots 9 and 20 indicates an advantage to this crop from the addition of a potash manure to artificials used alone, while the results on plots 6 and 7 indicate an advantage to this crop by adding artificials containing nitrogen and phosphates to 18 tons dung.

The barley crop of 1902 is considerably above the average. Even the unmanured plot produces a good crop (39 bushels), while the manured plots produce from 42¾ to 57¾ bushels. Artificials alone (plots 19-22), on the average, increase the barley crop by 6 bushels only, whereas the plots receiving dung alone give an average increase of 10¾ bushels, and dung and artificials an average increase of 14 bushels. The best barley crops have been produced by 18 tons dung and artificials (no potash) applied either to the swedes or the barley. The potash manure on plot 20 has not increased the barley crop (compare the results on this plot with those on plots 21 and 22). A striking result is the much smaller proportion of straw to grain on the manured than on the unmanured plots. While the plots receiving artificial manures only produce 15 per cent. more grain they actually produce 19 per cent. less straw than the unmanured plot, while on the dung only and dung and artificial plots the proportion of grain to straw is increased to a still greater extent. The results of this second rotation promise to be of a most interesting and useful character.

TABLE XII.—KIMBLESWORTH ROTATION EXPERIMENT. SECOND COURSE, FIRST AND SECOND YEARS.

PLOTS ⅛-ACRE. FIGURES PER ACRE.

Plot.	Manuring for swedes.					Manuring for subsequent crops :‡ barley, oats, hay, hay.*	Yield.			
	Dung.	Sulph. amm.	Super.	Slag.	Muriate of potash		Swedes, 1901.		Barley (1902).	
									Total grain.	Straw.
	Tons.	lb.	lb.	lb.	lb.		Tons.	cwt.	Bush. of 56 lb.	Cwt.
5	18	...	...	...	...	... ...	19	14	53¼	26
6	18	...	...	...	...	... ...	19	17¼	52	34
7	18	121	650	...	...	... ...	22	4	57¾	30¾
8	18	...	...	..	...	Artificials given to swedes on plot 7 spread equally over the four subsequent crops	20	9¼	57	32¼
9	12	60½	325	...	...	... ...	19	15½	52	26½
10	...	...	...	...	...	... ...	1	8	39	27
11	12	60½	325	...	...	Same as plot 8 for last cereal and last hay crop	20	9¼	52	21¾
12	12	...	...	...	...	Same as Plot 8	18	10	49¼	26
13	12	121	650	...	...	... ...	19	17½	50¾	24¾
14	12	121	...	570	...	... ...	20	9¾	50	24½
15	12	...	...	...	...	Same as plot 8, but slag instead of super.	19	1¾	47	26¾
16	12	...	...	...	...	... ...	19	13¼	49	27½
17	12	...	...	...	...	... ...	20	5	52½	20¾
18	12	...	...	...	...	... ...	17	2¼	45¼	23
†19	...	121	650	...	...	Same as plot 8 but in addition ¼ cwt. muriate to each crop	18	1¾	44	21½
†20	...	121	650	...	113	Same as 19	20	4½	42¾	21¾
21	...	121	650	...	...	... ...	17	13¾	46	22¼
22	...	121	650	...	...	... ...	19	0¼	47	22¾

The standard dressing, as supplied to plot 20 for the swede crop, consist of nitrogen, 25 lb.; phosphoric acid, 100 lb.; and potash 50 lb.

*In addition to the manures shown in the above table, all the plots receiving other artificials are to get about ¾ cwt. nitrate (12·5 lbs. nitrogen) for the last cereal crop and second hay crop.

†In the last rotation plot 20 was known as 19, and plot 19 as 20.

‡The rotation originally intended was swedes, barley, hay, hay, oats; but, owing to a misunderstanding, clover seeds were not sown with the barley, and, consequently, the sequence of crops had to be altered.

SPRAYING OF POTATOES TO CHECK DISEASE.

The following table gives the results of a small experiment made at Earl's House last season:—

TABLE XIII.

Kind of potatoes.	Saleable potatoes per acre.	
	Sprayed.	Unsprayed.
Langworthy	11 14¼	12 10¾
Up-to-date	10 17¾	11 2½

The ordinary sulphate of copper and lime mixture was used for spraying the potatoes, the spraying being done on July 29th. It will be seen that the effect of spraying has been to reduce the crop, as is often the case when the potatoes are only slightly attacked by the disease. In this case very few of the potatoes were affected with disease on the plots not sprayed, and there was no disease on the sprayed plots. The amount of unsaleable potatoes was small and about the same amount on each plot.

Experiments on the manuring of swedes and turnips.

These experiments have again been made as in previous years. The results are contained on Table XIV. (page 73). There are in all nine centres, eight in County Durham and one in Northumberland.

Centres and characters of soils:—

No. 1.—Mr. R. Wearmouth, Sherburn Colliery. The soil is a gravelly loam, lying on Boulder Clay, which is probably derived from the sandstones of the Coal Measures and from the Magnesian Limestone. Crop: Imperial Swede.

No. 2.—Mr. E. Waugh, Riffington, Cornhill-on-Tweed. The soil is a gravelly loam, lying on Boulder Clay, which overlies the Mountain Limestone. Crop: Improved Green Top Yellow Turnip.

No. 3.—Mr. T. Lister, Tudhoe, Spennymoor. The soil is a clay loam, lying on Boulder Clay, which overlies the Coal Measures. Crop: Best of All Swede.

No. 4.—Mr. J. W. Fell, Portrack Grange, Stockton. The soil is an alluvial loam (formerly an alluvial marsh), lying on Alluvium. Crop: Monarch Swede.

No. 5.—Mr. H. Simpson, High Rockcliffe, Croft. The soil is a strong loam, lying on Alluvium. Crop: Monarch Swede.

No. 6.—Mr. W. Gibson, Kelloe Hall, Coxhoe. The soil is a medium loam, lying on the Magnesian Limestone. Crop: XL All Swede.

No. 7.—Mr. T. J. Binks, Gore Hall, Thornley. The soil is a sandy loam, lying on the Magnesian Limestone. Crop: Kangaroo Swede.

No. 8.—Mr. P. Hett, Headlam Hall, Gainford. The soil is a gravel, lying on the Millstone Grit, with probably a slight admixture of Boulder Clay. Crop: XL All Swede.

No. 9.—Mr. H. Calendar, Bishopton, Stillington. The soil is a sandy loam, lying on Glacial Sands and Gravels, which are probably derived from the New Red Sandstone. Crop: Monarch Swede.

Plots were measured off and manures applied at two additional centres but the crop proved unsatisfactory in both these cases.

The objects of the experiments are:—To test the special needs of different soils for this crop; to compare super.. phosphatic guano, basic slag, and prec. bone phos. on different soils for this crop; and to ascertain the effects of light and heavy dressings of dung, with and without various dressings of artificial manures.

The results on Table XIV. are arranged under the various geological formations. It will be seen that very varying results are given on the different farms by the various manures. It is, therefore, desirable that the reasons for these differences should as far as is possible be made clear and an endeavour is made to do so in the following notes.

NOTES ON RESULTS.

The results at Riffington and Bishopton are not considered in the following notes, as they are evidently in high condition and, therefore, do not demonstrate the effects of the manures.

Varying needs of the different soils.—The swede crop has a special liking for phosphatic manure, and super. is the most generally useful manure for this crop. Light dressings of nitrogenous manure are usually profitable, but, as a rule, potash manuring is not necessary for this crop.

The results show that *phosphatic manures* are beneficial at all the centres (compare plot 6 receiving no phosphates with the best of plots 2, 3 and 4, at each centre, so as to get the most suitable phosphatic manure for each soil). It will be seen that the omission of phosphates at Portrack Grange gives actually a smaller crop than where no manures at all are applied, and on the Magnesian Limestone loam at Kelloe Hall reduces the crop to the level of the unmanured one, and also considerably reduces the crop at High Rockcliffe.

The omission of *nitrogenous manures* (nitrate and sulph. am.) in all cases materially reduces the crop, this being especially so on the sandy loam at Gore Hall (compare plots 4 and 5).

The *potash manure* (kainit) is very effective on the sandy Millstone Grit soil at Headlam Hall, where it increases the crop by nearly 7 tons an acre; it is not effective on the Magnesian Limestone soil at Gore Hall, but increases the crop by nearly 3 tons an acre on a similar soil at Kelloe Hall; it gives an increase of from 3 to 4 tons an acre on the alluvial soils at Portrack Grange and at High Rockcliffe; it actually decreases the crop, however, on the Boulder Clay loam at Tudhoe, but gives a small increase on the Boulder Clay soil at Sherburn Colliery, the soil here being comparatively light in character (compare plots 4 and 7).

Phosphates hunger is, therefore, most marked on the alluvial soil at Portrack Grange and on the Magnesian Limestone loam at Kelloe Hall. Prof. Middleton has pointed out in previous reports the tendency of the various soils lying on this formation to phosphate-hunger. In all cases, however, phosphates have given an increase of crop. Nitrogen is most wanted on the light soils at Headlam Hall and at Gore Hall, and also on the gravelly loam at Sherburn Colliery, and is useful at all the centres.

Potash-hunger is most marked on the light Millstone Grit soil at Headlam Hall, but the lack of potash is also felt at other centres already indicated. Usually the heavier soils do not respond to potash, especially the stiff Boulder Clay soils.

Effects of different phosphatic manures.—Super., basic slag, phosphatic guano, and prec. bone phos. are compared on plots 4, 3, 1 and 2. Super. does best at five of the nine centres; prec. bone phos. is best at two (Headlam Hall and Tudhoe); while slag is also best at two centres (but on these reliance cannot be placed owing to the high condition of the soil). Phosphatic guano, on plot 1, does not, on the whole, compare favourably with the other phosphatic manures and in no case does it give the best result. Plots 1-4 each receive the same amounts of manurial ingredients.

Light and heavy dressings of dung.—Twelve tons dung were applied on plot 10, and 18 tons on plot 9. The heavier dressing gives in all cases, except one, the best crop, but at one centre only (Portrack Grange) was the increase, by the heavier dressing, sufficient to be profitable. Excluding the two centres where the soil is in high condition the lighter dressing of dung has given good results, except on the strong alluvial soil at High Rockcliffe. This soil is probably rich in valuable organic matter, and is therefore less likely to respond to dung although it does so to artificials alone.

Dung and artificials.—Super. added to dung gives an increased crop by 3 tons at High Rockcliffe, an increase of 1 ton only at three centres and no increase at the remaining three. This is one of the most popular dressings for swedes, but at these centres, so far as the first crop of the rotation is concerned, the results are not satisfactory (compare plots 10 and 11). Kainit added to super. and dung (plot 12) has given irregular and not material results, but at the same time it is nearly as effective as super. added to dung. As dung, however, is comparatively rich in potash, it is not to be expected that a potash manure, in addition, will usually give good results. On the potash-lacking soil at Headlam Hall a small increase is given by the addition of kainit to dung. On plot 13 complete artificials (half-dressing of plot 4) are added to dung. This is equivalent to the addition of nitrogenous manures to plot 12, and, on the average, gives slightly better results than on this plot. The addition of each of the three manurial ingredients to dung on plots 11, 12 and 13 gives, in each case, a slight increase, with the result that when the addition of complete artificials to dung on plot 13 is compared with dung alone on plot 10, it is found that several of the centres show a few tons increase of crop by the addition of artificials. The artificials are likely to have good effects on succeeding crops of the rotation, as has been proved on several of the rotation experiments made by the College. Probably, therefore, the addition of complete artificials to dung will ultimately be profitable in the majority of cases. Plot 14 has double super. and kainit, but otherwise is the same as plot 13. This has given an increase of about 1 ton at three centres but no increase at the others.

Conclusions.—From these results it may be concluded that when artificials only are used for swedes it is advisable to apply "complete artificials" to light soils generally such as those lying on the Millstone Grit and on the Glacial Sands and Gravels. On heavier soils, however, such as those lying on stiff Boulder Clay and heavy Alluvium, the potash manure may generally be omitted.

On the lighter class of soils, therefore, the following will probably be a useful dressing per acre:—

1½ cwt. nitrate (or 1¼ cwt. sulph. am.).
5 „ super. (26 per cent.).
4 „ kainit (or 1 cwt. mur. potash).

TABLE XIV.—EXPERIMENTS ON THE MANURING OF SWEDES

RESULTS PER ACRE. PLOTS $\frac{1}{37}$-ACRE.

Plot.	Manuring.	Cost of Manures.		Boulder Clay.						Alluvium.				Magnesian Limestone.				Millstone Grit.		Glacial Sands and Gravels.		Plot.
				Sherburn Colliery. 1		Riffington. 2		Tudhoe. 3		Portrack Grange. 4		High Rockcliffe. 5		Kelloe Hall. 6		Gore Hall. 7		Headlam Hall. 8		Bishopton. 9		
		s.	d.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	
1	1 cwt. nitrate, ½ cwt. sul. of am., 4 cwt. kainit, 3 cwt. phosph. guano	40	4	14	0	25	5	16	1¾	18	4¼	19	0½	19	14	17	5¼	19	12	23	15¾	1
2	1 cwt. nitrate, ¾ cwt. sul. of am., 4 cwt. kainit, 2½ cwt. precip. bone phosph.	42	7	19	0	26	2½	17	3¼	16	14½	19	1¾	22	16	19	14½	21	14	23	15¾	2
3	1 cwt. nitrate, ¾ cwt. sul. of am., 4 cwt. kainit, 5 cwt. slag	39	6	17	0	28	7½	14	6¾	15	12¾	20	8¼	21	16¾	19	10	18	16½	24	19½	3
4	1 cwt. nitrate, ¾ cwt. sul. of am., 4 cwt. kainit, 7 cwt. super.	48	4	19	0	27	7½	16	11	21	11	23	1¾	23	0	20	5	19	6	22	4½	4
5	Nitrate and sul. of am. omitted, otherwise as plot 4	29	1	15	0	25	15	13	0	20	16½	17	5¾	20	5	13	10	15	5¾	19	8¼	5
6	Super. omitted, otherwise as plot 4	28	3	14	10	27	7½	12	5	9	9	14	10	13	9½	17	12¾	16	4¼	22	3¼	6
7	Kainit omitted, otherwise as plot 4	39	4	17	0	25	15	18	0½	17	4	20	5	20	4	20	12	12	10¾	21	1½	7
8	No manure	...		12	0	23	7½	8	18¼	14	4¼	11	3¼	12	18¼	16	2¾	13	1½	18	15	8
9	18 tons dung	90	0	17	10	28	7½	16	14¼	23	1¼	11	17½	23	4	21	12	18	13¼	24	16¾	9
10	12 tons dung	60	0	15	0	26	12½	14	0	19	0	12	2	22	1½	20	6¾	18	9½	22	14½	10
11	12 tons dung with 3½ cwt. super.	70	0	16	0	26	10	15	2¾	20	0¾	15	1	20	13½	19	6¼	18	0¼	22	15	11
12	12 tons dung with 3½ cwt. super. and 2 cwt. kainit	74	6	16	10	25	17½	17	3¾	22	18¼	16	1¾	20	12¾	20	14	19	7	20	9¼	12
13	12 tons dung with 3½ cwt. super. 2 cwt. kainit, ½ cwt. nitrate, and ⅜ cwt. sul. of am.	84	2	18	0	29	2½	19	0¾	21	12½	16	11	20	6¾	20	7	21	2	22	10¾	13
14	Same as plot 13, but with double super. and kainit	98	8	19	0	29	17½	16	15¾	21	10	15	16½	22	5	21	16½	22	7	22	1	14

On heavier soils the potash manure may generally be omitted without reduction of the crop.

All the manures may be applied in the drills, or half of the nitrate (if nitrate is used) may be reserved for topdressing after thinning the crop; and the potash manure will probably give better results if applied some time before the crop is sown, but after all ploughing previous to sowing has been done, so that the manure may not be buried too deeply.

When dung is used this alone will, in most cases, produce a fair crop of swedes, but the addition of a half-dressing of the artificials suggested above will usually be profitable if the crops that immediately follow the swede crop are taken into account.

Experiments on the manuring of mangels.

(C. Bryner Jones, M.R.A.S.E., F.H.A.S.)

Experiments on the manuring of mangels were conducted during last season at seven centres in the county of Durham. The crop at three of them, however, proved a failure, and was consequently not weighed. The names of the four centres to be reported upon, with notes on the character of the soil at each place, are given below:—

No.	Centre.	Owner or occupier.	Soil and geological formation.	Variety grown.
1	Little Stainton, Bishopton	Mrs. Wise	Clay, lying on Boulder Clay	Darlington globe.
2	Headlam Hall, Gainford	Mr. P. Hett	Strong loam with rough sand and gravel lying on Boulder Clay	Kent & Brydon's yellow globe.
3	White House, Lanchester	Mr. V. A. Ritson	Loam, lying on the Coal Measures	Yellow globe.
4	Hilton House, Hurworth-on-Tees	Mr. R. Thomson	Loam, lying on Alluvium.	Yellow globe.

The manures were applied at the time the crop was sown, except when otherwise stated in the table.

Objects.—The objects of the experiments were:—(1) To ascertain the most suitable artificial manures, and the quantities to be used in conjunction with dung; (2) to test the efficacy of salt as a manure for mangels.

Results.—The results of each centre are shown in Table XV.

TABLE XV.—EXPERIMENTS ON MANURING OF MANGELS IN COUNTY DURHAM, 1902.

RESULTS PER ACRE. PLOTS $\frac{1}{27}$-ACRE.

Plot.	Manuring.	Boulder Clay.				Coal Measures.		Alluvium.	
		1 Little Stainton.		2 Headlam Hall.		3 Lan-chester.		4 Hurworth-on-Tees.	
		T.	c.	T.	c.	T.	c.	T.	c.
1	12 tons dung	10	12½	17	13½	7	7½	11	2½
2	12 tons dung with half the artificials of plot 3	16	3¼	21	16½	8	5¾	11	1
3	12 tons dung with ⅞ cwt. sulph of am., 1⅛ cwt. nitrate, 4½ cwt. super., and ⅘ cwt. muriate of potash, all applied in drill	16	1¾	23	10	9	9	13	11¾
4	As for plot 3, but nitrate topdressed 3 to 4 weeks after singling	16	7½	24	7¼	10	0¾	12	9¾
5	As for plot 3, but with twice as much nitrate and sulph. of amm. All manures applied in drill	22	4¾	25	12½	10	1	15	16½
6	As for plot 5, but nitrate topdressed after singling	17	1½	23	8½	9	6¾	14	16¾
7	As for plot 3, but no nitrate or sulph. of amm.	11	14¾	17	9¾	8	0	9	11¾
8	As for plot 3, but 9 cwt. of super. ...	17	17½	23	3½	10	0	14	14
9	Do. do., but no super.	15	19	23	1	10	13	15	4
10	Do. do., but 1⅗ cwt. muriate of potash	14	11¾	22	4	9	12¾	15	8½
11	As for plot 10, but 6 cwt. kainit instead of muriate of potash	16	19	23	15¾	9	8¼	15	9¾
12	As for plot 3, but no muriate of potash	15	5	20	16	8	4¼	13	14¾
13	As for plot 12, with 3 cwt. salt in addition	15	16	21	15	*	—	14	10¼
14	As for plot 3, with 3 cwt. salt in addition	18	17¾	20	11	*	—	14	11
15	No manure.	9	10¾	16	5	*	—	8	15¾

* Through a misunderstanding, plots 13, 14, and 15 were not weighed at Lanchester.

The crops varied a good deal as is usually the case. This was partly due, no doubt, to the nature and condition of the soil. It was obviously in a high state of fertility at Headlam Hall, where there was a crop of over 16 tons to the acre on the unmanured plot, while there was very little more than half that quantity on the corresponding plots at the other centres. Taking into consideration the unfavourable character of the season, the produce may be regarded on the whole as fairly satisfactory.

The cost of the manure and the average crop at three centres are given in Table XVI. Owing to the last three plots at Lanchester not having been weighed, this centre is not included in the averages.

TABLE XVI.—MANGEL EXPERIMENTS, 1902.

AVERAGE CROP AT THREE CENTRES AND COST OF MANURES PER ACRE.

Plot.	Manure per acre.	Cost of Manure.			Average crop at 3 centres.		Increase over unmanured plot.	
		£	s.	d.	T.	c.	T.	c.
1	12 tons dung	3	0	0	13	3	1	12½
2	12 tons dung with half artificials of plot 3	4	0	4	16	7	4	16½
3	12 tons dung, with 1⅛ cwt. nitrate of soda, ⅞ cwt. sulph. am., 4½ cwt. super., and ⅘ cwt. mur. potash, all in drill	5	0	9	17	14½	6	4
4	Do. do. do. do., but nitrate topdressed, 3 and 4 weeks after singling	5	0	9	17	15	6	4½
5	As for plot 3, but with twice as much nitrate and sulph. am., all in drill	6	2	10	21	4½	9	14
6	As for plot 5, but nitrate top-dressed after singling	...			18	12	7	1½
7	As for plot 3, but no nitrate or sulph. am.	3	18	8	12	19	1	8½
8	As for plot 3, but 9 cwt. super.	5	12	3	18	11⅔	7	1
9	As for plot 3, but no super.	4	9	3	18	1⅓	6	11
10	As for plot 3, but 1⅗ cwt. mur. potash ...	5	7	11	17	8	5	17½
11	As for plot 10, but 6 cwt. kainit instead of mur. potash	5	7	1	18	15	7	4½
12	As for plot 3, but no mur. potash... ...	4	13	7	16	18½	5	8
13	As for plot 12, with an addition of 3 cwt. salt	4	16	7	17	7	5	16½
14	As for plot 3, with 3 cwt. salt	5	3	9	18	0	6	9½
15	No manure	...			11	10½	...	

As will be seen, the heaviest crop was produced on plot 5, where double the quantity of nitrate and sulph. am. was used. Taking the results as they appear in the above table and at the individual centres, they show:—

1. That 12 tons dung has not produced a great increase over the unmanured plot, except at Hurworth-on-Tees (compare plots 1 and 15).
2. That complete artificials added to dung have greatly increased the crop at Little Stainton and Headlam Hall but not at the other two centres; and that half the artificials with dung has done nearly as well as the complete dressing (plots 1, 2 and 3).
3. That where the nitrate (1½ cwt.) was applied as a topdressing, after singling, the results were better in three out of four centres than where it was applied at the time of sowing the crop (plots 3 and 4); but where the double dressing of nitrate (2¼ cwt.) was applied as a topdressing, this was not so effective as when applied at the time of sowing (plots 5 and 6). It is evident, therefore, that topdressings of more than 1 cwt. of nitrate at one time are not desirable.
4. That the double application of nitrogenous manures (nitrate and sulph. am.) materially increased the crop when applied at the time of sowing (plots 3 and 5); and that when no nitrogenous manures were applied the crop was materially reduced (plots 3 and 7). A comparison of the results on plots 5 and 7 shows that the double dressing of nitrogenous manures actually increased the crop by 10½ tons an acre at Little Stainton.
5. That a double application of phosphatic manure has not materially increased the crop (plots 3 and 8); and that the withholding of this manure altogether has resulted on the average in an increase of crop (plots 3 and 9).

6. That a double application of potash manure (mur. potash) has given a smaller crop at two centres, and a material increase at one centre only (plots 3 and 10); that when the double application of potash was in the form of kainit the crop was materially better at Little Stainton and Headlam Hall; and that where no potash was applied the crop was, on the average, considerably reduced (plots 3 and 12).
7. That common salt has had an excellent effect at Little Stainton but not at the other centres; the results with this are not of a conclusive character.

General manuring for mangels.—These results confirm the general opinions as to the manuring of the mangel crop. A moderate dressing of dung combined with a complete dressing of artificial manures is generally required for this crop. Unlike the swede crop, however, the special requirement for mangels is nitrogenous and not phosphatic manuring. This crop will generally respond well to a dressing of 1 cwt. nitrate and 1 cwt. sulph. am. per acre at the time of sowing and another 1 cwt. nitrate as a topdressing after singling.

The soils at all the centres are rather heavy in character, but, notwithstanding this, the potash manures have been, on the whole, useful. Where potash was withheld, however, the crop has not suffered nearly so much in any case as on the Millstone Grit soil at Cockle Park last season. It is also evident that some of the heavier soils respond to potash when mangels are the crop to be grown, although the same soil would not respond to potash applied to pasture or swedes; and further, phosphatic manures may not be wanted on these soils for mangels, although they may give excellent results on the same soils when applied to pasture or a swede crop.

Experiments on the manuring of potatoes.

(C. BRYNER JONES.)

Experiments on the manuring of the potato crop were carried out during season 1902, at seven centres in the county of Durham. The character of the soil and other particulars relating to the different centres, are shown below.

No.	Centre.	Owner or Occupier.	Soil and geological formation.	Variety grown.
1	Broomside House, Sherburn Colliery	Mr. T. Cleasby...	Strong loam, lying on Boulder Clay	Scottish Triumph
2	Headlam Hall, Gainford	Mr. P. Hett ...	Gravelly loam on Boulder Clay	Bruce.
3	Denton Hall, Denton	Mr. W. P. H. Dods	Loam on Boulder Clay	Bruce.
4	Sherburn Colliery	Mr. R. Wearmouth	Gravelly loam on Boulder Clay, which is probably derived from sandstones of Coal Measures and Magnesian Limestone	British Queen
5	Thornley Moor, Thornley	Mr. G. Dobson...	Strong loam on Boulder Clay with probably a slight admixture of Magnesian Limestone	Up-to-date
6	Murton Moor Farm, Murton Junction	Mr. W. Hill ...	Gravelly loam on Glacial Sands and Gravels with probably a slight admixture of Boulder Clay	Up-to-date
7	Portrack Grange, Stockton	Mr. J. W. Fell...	Alluvial loam (formerly a marsh) lying on the Alluvium	Garton's Abundance

Objects.—The objects of the experiments were:—(1) To indicate the most necessary class of manure for producing a satisfactory crop of potatoes under the conditions prevailing in the county; (2) to test the value of potash from different sources; (3) to compare the effects of dung and artificial manures; (4) to ascertain to what extent it is profitable to use artificials and dung together for potatoes.

Soil.—The soil, as already shown, varied considerably at the different centres, and that not only in physical character but in fertility as well. At two centres, Denton Hall and Portrack Grange, there was a heavy crop on the unmanured plot, which, seeing that several of the manured plots produced less than that which had received no treatment whatever, renders the results at these two centres useless for purposes of comparison. They are, therefore, both omitted from the averages. It is well known that results of field experiments on land in good condition are frequently very erratic in character, and show that certain manures may do actual harm under such circumstances. Results of this kind, however, although they appear contradictory, and cause many to regard field experiments as being of no practical use, are not without value in certain cases. They show clearly that it is possible, by certain methods of manuring, to disturb that proportion in which the elements of plant food appear to be taken up by the crop, and which, in order to produce a crop successfully, seems to be almost as important as a sufficiency of nutrition. By showing what manures are most likely to cause this diminution in the crop, and the class of soils on which it is most likely to happen, results of this kind may often yield useful information; and it does not necessarily follow that because the results are not exactly what was looked for, the experiment is to be regarded as a failure from the practical standpoint.

An attempt was made last season with several experiments to discover whether the effects of the different manures used

TABLE XVII.—EXPERIMENTS ON THE MANURING OF POTATOES IN CO. DURHAM DURING SEASON 1902.

RESULTS PER ACRE. PLOTS $\frac{1}{27}$-ACRE.

Plot.	Manure per acre.	Produce per acre.						
		Boulder Clay.					Glacial Sands and Gravels.	Alluvium.
		Broomside House.	Headlam Hall.	Denton.	Sherburn Colliery.	Thornley.	Murton.	Portrack Grange.
		T. c.	T. c.	T. c.	T. c.	T. c.	T. c.	T. c.
1	18 tons dung	8 6 (1 15)	5 16¾ (1 11½)	... ..	2 17¾ (2 19½)	7 1½ (1 0¼)	7 7¾ (2 5¾)	8 2¾ (2 0½)
2	12 tons dung	6 17¾ (2 1½)	5 3¼ (1 13½)	9 9 (0 11)	2 0 (3 2½)	4 1¼ (1 1)	6 18½ (1 18¼)	8 5 (1 14½)
3	12 tons dung with half the artificials of plot 5 ...	7 7½ (2 0¾)	5 12¼ (2 5)	10 9¼ (0 13½)	2 10 (3 1¾)	5 10¾ (1 7½)	6 7½ (1 13¼)	7 18¼ (1 15½)
4	12 tons dung with the artificials of plot 5	7 16¾ (1 12½)	7 5¼ (2 2½)	9 14¾ (1 4½)	2 16½ (2 6½)	8 3½ (1 19¼)	6 6½ (2 7½)	8 0 (2 1)
5	1⅛ cwt. nitrate, ⅞ cwt. sulph. am., 3½ cwt. super., and 1 cwt. mur. potash	6 14¾ (1 14¾)	4 4¼ (2 3½)	10 18½ (0 14)	2 15¼ (2 19)	6 1½ (1 7¾)	5 19¾ (1 11½)	7 7½ (1 15½)
6	2 cwt. mur. potash, otherwise same as plot 5 ...	5 10¼ (2 0¾)	6 1¾ (1 7½)	9 9¾ (0 14¼)	1 16¾ (3 4½)	6 17¼ (1 5¼)	5 3½ (2 4½)	7 0 (1 15¾)
7	3 cwt. sulph. potash instead of 2 cwt. muriate, otherwise same as plot 5	5 5¼ (1 19¾)	6 1 (1 7¼)	9 11½ (0 7½)	1 17¼ (3 6¾)	6 16½ (0 19¾)	5 6½ (1 5)	5 19¼ (1 7½)
8	8 cwt. kainit instead of 2 cwt. mur. potash, otherwise same as plot 5	5 10 (1 4½)	4 4 (1 19¼)	8 17½ (1 2½)	2 2¼ (2 9½)	6 6½ (0 17½)	4 1 (1 12¾)	7 7¾ (1 6½)
9	No manure	2 0¼ (1 7½)	1 4 (1 11¾)	8 7¼ (0 17¼)	1 0 (2 12½)	2 19¾ (0 15)	1 16 (0 17½)	6 17½ (1 10¼)
10	Nitrate and sulph. am. omitted, otherwise same as plot 5	3 1¾ (1 15½)	1 14 (1 15¾)	5 11¾ (1 2¾)	0 15 (2 16)	3 9¼ (0 10)	3 3½ (1 13½)	6 1 (1 14)
11	Super omitted, otherwise same as plot 5	4 1 (1 6¾)	2 16¾ (1 12¼)	8 1¾ (0 10¾)	1 16½ (2 16½)	3 8½ (0 11)	3 19¼ (0 16¾)	6 14¼ (1 11½)
12	Mur. potash omitted, otherwise same as plot 5 ...	3 5¼ (1 12¼)	2 13¼ (1 10¼)	8 10¼ (0 12¾)	2 6 (2 14)	5 2½ (0 18½)	2 12¼ (2 1)	8 4 (1 14½)

N.B.—The figures in brackets show the quantity of small and "seed" potatoes vary with the geological formation. In Table XVII. the results of the potato experiments are arranged with a view of showing the formation underlying the soil at each of the centres where the experiments were carried out. Five of the centres were on the Boulder Clay, and the other two were on the Glacial Sands and Gravels, and Alluvium respectively. It will already have been observed from the remarks in the above table that the physical character of the soil varied a good deal on the Boulder Clay, which accounts, perhaps, for the fact that the experiments have yielded no striking results

TABLE XVIII.—POTATO EXPERIMENTS, 1902.

AVERAGE CROP AT 5 CENTRES, WITH COST OF MANURE AND PROFIT PER ACRE.

Plot.	Manure per acre.	Cost of manure.			Average crop at 5 centres.				Increase of saleable potatoes, unmanured plot.		Profit due to manure, potatoes at £3 per ton.		
					Saleable.		Seconds.						
		£	s.	d.	T.	c.	T.	c.	T.	c.	£	s.	d.
1	18 tons dung	4	10	0	6	8	1	3⅘	4	15	9	17	1
2	12 tons dung	3	0	0	5	2¾	1	19¼	3	10½	7	11	6
3	12 tons dung with half the artificials of plot 5	4	0	6	5	9⅗	2	1¾	3	17¼	7	11	4
4	12 tons dung with the artificials of plot 5	5	1	1	6	9½	2	1⅜	4	17¼	9	10	2
5	1⅛ cwt. nitrate, ⅞ cwt. sulph. am., 3½ cwt. super., and 1 cwt. mur. potash	2	1	1	5	3⅒	1	17¾	3	10⅘	8	11	3
6	2 cwt. mur. potash, otherwise same as plot 5.	2	10	1	5	$0\frac{7}{10}$	2	0⅖	3	8½	7	15	5
7	3 cwt. sulph. potash instead of mur., otherwise same as plot 5	3	2	10	5	1¼	1	15¾	3	9	7	4	2
8	8 cwt. kainit instead of mur. potash, otherwise same as plot 5.	2	10	1	4	8¾	1	12½	2	16½	5	19	5
9	No manure		—		1	12¼	1	12⅘		—		—	
10	Nitrate and sulph. am. omitted, otherwise same as plot 5.	0	19	0	2	$8\frac{7}{10}$	1	15¼	0	16⅖	1	10	2
11	Super. omitted, otherwise same as plot 5	1	11	0	3	4¼	1	8¾	1	12	3	5	0
12	Mur. potash omitted, otherwise same as plot 5	1	12	1	3	4	1	15¼	1	11¾	3	3	1

in this particular respect. In the table showing the averages, the results on the different geological formations are all taken together, with the exception of the two centres already named, which are omitted for other reasons.

Results.—The manures used, and the yield at the various centres are shown in Table XVII.

As might be expected, the results vary a good deal. The crops must be regarded, on the whole, as light, which was largely due no doubt to the wet season. The average crop per acre at five centres, and other particulars are given in Table XVIII.

The most necessary class of manure.—It is well known that on certain kinds of land certain manurial ingredients give better results than others with particular crops, and one of the lessons to be learnt by means of field experiments is the most necessary manure to apply to the soil of a particular farm, or a particular field, in order to produce the best crop. This applies especially, of course, to artificial manures. The results with potatoes during last year in this connection are shown below.

Plot.	Manure per acre.	Cost of manure.			Average crop of saleable potatoes at five centres.		Increase over unmanured plot.		Profit due to manure, potatoes at £3 per ton.		
		£	s.	d.	T.	c.	T.	c.	£	s.	d.
9	No manure	—			1	12¼	—		—		
5	1⅛ cwt. nitrate, ⅞ cwt. sulph. am., 3½ cwt. super., and 1 cwt. mur. potash (complete manure)	2	1	1	5	3⅒	3	10⅘	8	11	3
10	Same as plot 5 but **no nitrogen**	0	19	0	2	8 7/10	0	16⅖	1	10	2
11	Same as plot 5 but **no phosphates**	1	11	0	3	4¼	1	12	3	5	0
12	Same as plot 5 but **no potash**	1	12	1	3	4	1	11¾	3	3	1

The results agree with those obtained in 1901. There was a profit of £8 11s. 3d. per acre on the plot which had received a complete manure, as compared with the unmanured plot. When nitrogen was omitted, the profit was reduced to £1 10s. 2d., showing, in a most remarkable way, the value of nitrogen for the potato crop on the soils under experiment. There was also a large decrease in the profit caused by omitting phosphates and potash. The figures in both these cases are practically the same, but of the two the omission of potash has made the greater difference. As a rule, phosphates are not so very necessary on most soils for successful potato growing as potash and nitrogen. This experiment bears this out, but not so strikingly as in 1901, when there was an actual loss of 11s. per acre on the plot which had received no potash as compared with a profit of £6 1s. on the plot which had received a complete manure. The omission of phosphates made much more difference in the yield last season than in 1901, and the omission of nitrogen still more. While the results for that year indicated that nitrogen and potash were the most necessary ingredients in a potato manure, and of the two that potash was by far the more important, the experiments last season show that the omission of phosphates also caused a serious decrease in the profit. But they agree with those of 1901 in showing that nitrogen, and potash to a lesser extent, are more necessary than phosphates. In this connection it is to be observed that the saleable potatoes only are taken into consideration. When we take the total produce, the results seem to indicate that phosphates were to some extent more necessary than potash. Viewing these results in the light of previous experiments, it is to be assumed that while phosphates are needed on some soils, potash and nitrogen are necessary on most soils for potatoes and particularly nitrogen. It is the lighter class of soils that usually derive most benefit from potash.

It is instructive in this connection to note the results at Denton and Portrack Grange. At both these centres potash did actual harm, for on plot 12 in both cases, where no potash was used, there was an increase as compared with the unmanured plot. The soils at these two centres are loam on Boulder Clay, and Alluvium respectively, and the unprofitable use of potash is not, therefore, at variance with what might have been anticipated. As compared with nitrogen, potash was less effective also on the Boulder Clay at Broomside, and it is to be noted that, with two exceptions, doubling the dressing of potash was attended with a decrease in the crop. The omission of nitrogen from the manure has consistently reduced the crop. It is possible that the wet and cold summer last year had a good deal to do with this. The nitrogen was supplied last season partly in nitrate and partly in sulph. am. Previous experiments had shown this to be the most satisfactory method, and the quantities used on plot 5 to be quite sufficient for ordinary use.

The effects of potash from different sources.—The potash manures in common use seem to vary in their effect upon the potato crop, and it is of considerable practical importance to ascertain the most satisfactory form in which to apply potash to the crop, especially in view of the great value of this ingredient for potatoes on a certain class of soils. Last season the same quantity of potash was supplied in three different manures. The results are shown in the following table:—

The results here again to a great extent confirm those of previous years. Kainit is the least satisfactory of the three manures. Between the yield caused by muriate and sulph. potash respectively there is not much difference. But owing to the difference in the cost, muriate was more profitable last year, and taking everything into consideration, therefore, it proved itself superior to the other two, as it did the previous year. It is to be noted, however, that at Broomside, kainit did practically as well as muriate and better than sulphate of potash, while at Sherburn Colliery and Portrack Grange, it proved superior to both. But although in actual weight of produce, kainit may often compare favourably with the other potash manures named, it not infrequently impairs the quality of the crop, and its use as a manure for potatoes is not to be recommended.* Mur. potash might be expected perhaps to give better results in dry, and sulphate in wet, seasons. In the dry summer of 1901, muriate certainly did have a better effect than sulphate. But, although the summer of 1902 was wet, sulphate did not, if we include all the centres, produce any better results than muriate. Indeed, the advantage is slightly in favour of the latter. In the above table, where only five centres are considered, there is a difference of ½ cwt. to the acre in favour of sulphate of potash.

Plot.	Manure per acre.	Cost of manure.			Average crop of saleable potatoes at 5 centres.		Increase over unmanured plot.		Profit due to manure, potatoes at £3 per ton.		
		£	s.	d.	T.	C.	T.	C.	£	s.	d.
9	No manure		—		1	12¼		—		—	
6	Complete artificial manure containing 2 cwt. **mur. potash**	2	10	1	5	0¾	3	8½	7	15	5
7	Do. do., containing 3 cwt. **sulph. potash** instead of mur.	3	2	10	5	1¼	3	9	7	4	2
8	Do. do., containing 8 cwt. **kainit** instead of mur.	2	10	1	4	8¾	2	16½	5	19	5

Dung v. artificial manure.—It will have been seen that the plots which received farmyard manure alone produced very satisfactory results last year as compared with the other plots. Plot 1, which received 18 tons to the acre produced the biggest profit of all. The effects of dung alone and artificials alone are shown in detail in the following table:—

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* See Mr. Collins' report, page 117.

Plot.	Manure per acre.	Cost of manure.			Average crop of saleable potatoes at 5 centres.		Increase over unmanured plot.		Profit due to manure, potatoes at £3 per ton.		
		£	s.	d.	T.	C.	T.	C.	£	s.	d.
9	No manure		—		1	12¼		—		—	
1	18 tons dung...	4	10	0	6	8	4	15¾	9	17	1
2	12 tons dung...	3	0	0	5	2¾	3	10½	7	11	6
5	1⅛ cwt. nitrate, ⅞ cwt. sulph. am., 3½ cwt. super., and 1 cwt. mur. potash	2	1	1	5	3$\frac{1}{10}$	3	10⅘	8	11	3

In previous experiments, artificial manure alone has often given better results than dung, and it was so last season where no more than 12 tons of dung per acre was used. The figures here given show that potatoes may be successfully grown without dung, and that, as intimated in the Report for 1901, "in view of this result it would be unwise to rob the fallow break of its manure for the sake of the potato crop," if there should at all be a scarcity of dung on the farm. Where the farmer has, on the other hand, plenty of dung at his disposal, and can apply it at the rate of 18 tons to the acre, such a dressing would probably repay him. Previous experiments have shown that it is not always economical to use as much as 18 tons of dung per acre. The profit from that amount last season was certainly substantial, but it is to be noted that, as compared with 12 tons, the profit is not altogether in proportion to the cost of the manure in the two cases. If the total crop is considered, there was only 10 cwt. per acre more on plot 1 than plot 2. From that standpoint, the additional 6 tons dung applied to plot 1 might, with much greater advantage, have been used for some other crop. But taking the saleable potatoes only, the heavier dressing of dung certainly produced better results.

Artificials used alone last season proved very satisfactory. They gave a profit of 20s. per acre more than 12 tons dung. It is true that as far as the actual profit goes, they do not come up to plot 1, where 18 tons dung was used. But it is interesting to note that the ratio of profit to the cost of the manure is much higher with the artificials, and in that sense they paid better. In any case, they compare very favourably even with the heavier dressing of dung, and were much more profitable than the moderate dressing of dung used on plot 2.

Artificials and dung together.—The extent to which artificial manure may be used in conjunction with dung is a question of much importance to the practical farmer, and one which has often been discussed. It has more than once been pointed out in these Reports that when moderate dressings of dung are used, it does not as a rule pay directly to add much artificial manure. The results with potatoes last season are summarised below:—

Plot.	Manure per acre.	Cost of manure.			Average crop of saleable potatoes at 5 centres.		Increase over unmanured plot.		Profit due to manure, potatoes at £3 per ton.		
		£	s.	d.	T.	c.	T.	c.	£	s.	d.
2	12 tons dung...	3	0	0	5	$2\frac{3}{4}$	3	$10\frac{1}{2}$	7	11	6
3	12 tons dung with half artificials of plot 5	4	0	6	5	$9\frac{3}{5}$	3	$17\frac{1}{4}$	7	11	4
4	12 tons dung and artificials of plot 5	5	1	1	6	$9\frac{1}{2}$	4	$17\frac{1}{4}$	9	10	2
5	Complete artificials	2	1	1	5	$3\frac{1}{10}$	3	$10\frac{4}{5}$	8	11	3

The dung and artificials applied to plot 4 increased the produce by 27 cwt. of saleable potatoes to the acre as compared with plot 2. This increase was sufficient to cover the extra cost of the artificials, and leave at the same time a profit of 38s. 8d. per acre. As far as the actual profit goes, therefore, it is evident that in this case it has paid to use artificials along with dung, when the same dressing was used as that applied by itself to plot 5. At Thornley, the addition of a full dressing of artificials to 12 tons dung nearly doubled the crop. It increased the average considerably, but owing to its greater cost, the profit from this dressing was not equal to that from 18 tons dung.

The addition of a half-dressing of artificials on plot 3 also increased the crop as compared with dung alone, but the increase in saleable potatoes was only just sufficient to cover the cost of the extra manure. There was thus no practical advantage in using it.

Conclusion.—It has been shown that the biggest profit last year, taking only the saleable potatoes, was obtained from 18 tons dung (plot 1). The next best profit was obtained from 12 tons dung with complete artificials (plot 4), and this is followed by artificials alone (plot 5). It is interesting, however, to note that when we take into consideration the cost at which this profit has been produced, the relative positions of these three plots are completely altered as shown below:—

£1 worth of manure on plot 1 produced a profit of £2 3s. 3d.
,, ,, 4 ,, ,, £1 18s. 0d.
,, ,, 5 ,, ,, £4 0s. 0d.

Relatively to the cost of the manure, therefore, artificials alone gave a better return per acre than any other dressing used; and dung and artificials together, judged from this standpoint, were the least satisfactory.

Experiments on Seeds Hay.

(C. Bryner Jones.)

I.—EXPERIMENTS WITH NITROGENOUS MANURES.

No.	Farm.	Owner or Occupier.	Remarks.
1	Bishopton, Ferryhill	Mr. Wm. Elders	Good even take after barley
2	Headlam Hall, Gainford	Mr. P. Hett	Good take; gravelly soil
3	Tudhoe, Spennymoor	Mr. A. Simpson	Very good take; loamy soil
4	Do. do.	Mr. Thos. Lister	Very good take; loamy soil

The objects of the experiment were:—(1) To test nitrate, sulph. am., and a mixture of both as topdressings for seeds hay, and (2) to ascertain the effects of early and late topdressing on the clover in the aftermath and on the ryegrass on the first crop. According to previous reports, it was observed at Cockle Park and elsewhere in 1901 that early topdressing with nitrogenous manures produced a better quality of ryegrass, but that the clover in the aftermath suffered much more under these circumstances than when the topdressings were applied later in the season. It was largely in order to gain information as to the reason why nitrogenous manures have this effect upon clover, that this experiment was carried out.

The scheme of the manuring and the produce obtained at each centre will be seen in Table XIX. It will be observed that the plots are in two sets, A and B, and that the A plots were manured about three weeks earlier than the B plots. The

TABLE XIX.—EXPERIMENTS IN THE MANURING OF SEEDS HAY IN CO. DURHAM, 1902.

RESULTS PER ACRE.

Plot.	Manure per acre.	Cost of manure.		Bishopton.		Headlam Hall.	Tudhoe. (Mr. A. Simpson.)	Tudhoe. (Mr. T. Lister.)		Average of 1st crop at 3 centres.	Increase over average of unmanured plot at 3 centres.	Value of increase at £3 per ton.		Profit (+) or loss (–) due to manure.	
				1st crop	2nd crop			1st crop	2nd crop						
		s.	d.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt	Cwt.	Cwt.	Cwt.	s.	d.	s.	d.
1A	No manure	—		68¼	32	37¼	43¾	50½	9½	54⅙	—	—		—	
1B	No manure	—		55½	29¾	47½	39½	54½	10½	49⅚	—	—		—	
2A	1½ cwt. sulph. am. applied March 25th	17	7½	75	28¾	44¼	51¼	56½	12	60 11/12	8 11/12	26	9	+ 9	1½
2B	1½ cwt. sulph. am. applied 3 weeks later	17	7½	61	27¼	45	43¾	55½	10¾	53 5/12	1 5/12	4	3	–13	4½
3A	2 cwt. nitrate applied April 10th	21	0	72¼	28½	42¾	49	58¾	10¾	60	8	24	0	+ 3	0
3B	2 cwt. nitrate applied 3 weeks later	21	0	65½	27½	46¾	44	55¼	12	54 11/12	2 11/12	8	9	–12	3
4A	¾ cwt. sulph. am. applied March 25th, and 1 cwt. nitrate applied April 10th	19	4	77¾	33	45	48¾	56	11½	60 11/12	8 11/12	26	9	+ 7	5
4B	¾ cwt. sulph. am. applied 3 weeks after March 25th, and 1 cwt. nitrate applied 3 weeks after April 10th	19	4	65¼	26¾	45½	46¼	54	11¾	55⅙	3⅙	9	6	– 9	10
5A	⅜ cwt. sulph. am. applied March 25th, and ½ cwt. nitrate applied April 10th	9	8	66	29¼	37½	47¼	57¼	11	56⅚	4⅚	14	6	+ 4	10
5B	⅜ cwt. sulph. am. applied 3 weeks after March 25th, and ½ cwt. nitrate applied 3 weeks after April 10th	9	8	63¼	34	47½	45½	55½	10½	54¾	2¾	8	3	– 1	5

manures on plot 5B at Headlam Hall, however, were by a mistake applied on the same date, and this centre is, therefore, left out of the "average" column in the table showing the results. It was intended to weigh both the first and second crops, but this was done at two only out of the four centres owing to bad weather and the lateness of the season.

The figures in the above table show with remarkable consistency the advantage of applying sulph. am. and nitrate fairly early in the season, as far, at least, as the weight of the hay crop is concerned. This applies in particular to the first cut. When we come to the second cut, the results are slightly different, but in the majority of cases, the same thing applies here also. But while the results at Bishopton and the two Tudhoe centres show the advantage of applying nitrogenous manures to seeds hay early in the season, such a course at Headlam Hall has in all cases diminished the crop. The land under experiment at this centre, however, was somewhat variable, and, as already stated, a mistake was also made with the manures on one of the plots; the results here are, therefore, not altogether reliable, and it is unsafe to draw any conclusions from them. At all the other centres the land was quite uniform in character, and there was a very even "take" of seeds.

Taking sulph. am. and nitrate individually, the former has proved the more profitable manure, for while sulph. am. gave a profit of slightly over 9s. to the acre nitrate gave only a profit of 3s. It is very important here, however, to take into consideration the time of application. The above table clearly shows that only when the manures were applied early was there any financial gain. Late applications were in all cases followed by a loss, which in some cases amounted to a very considerable figure. Sulph. am. should be applied not later than about the 25th March. If it gets well on into April before any manure has been applied, it seems clear that nitrate would, as a rule, be the safer manure to use under-such circumstances, but it is equally clear that if nitrate is applied much later than the 10th April the results will be unsatisfactory, and may show a very considerable loss.

The plots at each centre were visited late in the summer with a view of ascertaining the effect of early and late dressings respectively on the clover in the aftermath. It cannot be said that the experiments have yielded any striking, or even very satisfactory, results in this respect. At each centre there were several plots with practically no difference between them and from which, therefore, nothing could be learned. Further experiments are necessary before any definite information may be obtained on this particular point. There are, however, one or two other points connected with the more general effects of the manures used that may be noticed. At Headlam Hall and the two centres at Tudhoe, there was decidedly less clover in the aftermath on the manured plots than on the unmanured ones. This is often the case when nitrogenous manures only are used, and the experiment, in this respect, confirms results frequently obtained before. It would appear also that, on the whole, the mixed dressings had had a slightly less injurious effect in this respect at all the centres than where sulph. am. and nitrate were used separately, although it is not the same mixed dressing which has the advantage throughout. At Bishopton, leaving the unmanured plots out of consideration, the best plot at the time of inspection was 4A; at Headlam Hall, 5B; and at the two Tudhoe centres, 4B and 5A respectively.

If any conclusion at all may be drawn from these experiments with respect to the effect of early and late dressings of nitrogenous manures on the clover in the aftermath, it is that the time of application makes very little difference. But, as already observed, it would be unsafe to draw any definite conclusions until further trials have been carried out.

II.—EXPERIMENT WITH KAINIT.

An experiment to test the efficacy of "early" and "late" applications of kainit to seeds hay was carried out at Earl's House, Durham. The plots were each one-third of an acre in area. Three of the plots were dressed on February 7th, and the other three on March 27th. The quantity of kainit applied was the same in each case, and was equal to a dressing containing 50 pounds of potash to the acre. The field where the experiment was carried out had previously been dressed with basic slag at the rate of 5 cwt. per acre.

The plan of manuring and the produce obtained on the different plots are shown in the following table:—

TABLE XX.

Plot.	Manure per acre.	When applied.	Cost of manure.	Produce.		
				1st crop.	2nd crop.	Total.
			s. d.	Cwt.	Cwt.	Cwt.
1	412 lb. kainit	Feb. 7	8 3	41⅞	16	57⅞
2	Do.	March 27	8 3	35¾	13¼	49
3	Do.	Feb. 7	8 3	38¾	14½	53¼
4	Do.	March 27	8 3	37¼	15¾	53
5	Do.	Feb. 7	8 3	40½	17	57½
6	Do.	March 27	8 3	34⅜	16½	50⅞

It will be seen that, as in the case of the nitrogenous manures, the early applications of kainit have throughout produced heavier crops than the late applications, except in the case of the second crop on plots 3 and 4. The remarkable consistency of the results in this and the preceding experiment is worthy of note. In both cases the advantage of applying the manures dealt with "early" is most clearly shown. It is to be noted, however, that the terms "early" and "late" are not synonymous in the two cases. The end of March may be regarded as "early" for nitrogenous manures, particularly nitrate, but this would be "late" for kainit. As far as the results of the experiment under notice go, it is obvious that kainit should not be applied to seeds hay much later than the first week in February. This may be quite clearly seen from the table above but more conveniently perhaps from the following table, where the results are summarised:—

Plots.	Kainit applied.	Average produce.	Value of produce at £3 per ton.
		cwt.	£ s. d.
1, 3 and 5.	February 7.	56¼	8 8 9
2, 4 and 6.	March 27.	51	7 13 0

The "early" applications have produced on an average 5¼ cwt. more hay per acre than the "late" dressings. When the produce is valued at £3 per ton, this leaves a sum of 15s. 9d. per acre in favour of the kainit applied on 7th February as compared with that applied seven weeks later. These results, as well as those yielded by the nitrogenous manures in the experiment already described, should prove of much interest to those who use artificial manures for seeds hay.

Report of the Lecturer in Agricultural Chemistry for 1902.

(S. H. Collins, F.I.C., F.C.S.)

This report contains the result of the chemical work done during the season 1902 so far as it has been completed, together with that part of the work of former seasons which has been held back for completion or verification.

The greater part of the work deals with the feeding value of swedes. The results obtained fully account for the well-known fact that some farmers are very successful with feeding swedes whilst others consider them unprofitable.

Some varieties of swedes are much richer than others (page 102).

Some farms grow richer swedes than other farms do (page 105).

METHODS OF ANALYSIS.

Some notes on the methods of analysis that have been employed were printed in former reports (1900, page 179; 1901, page 94).

Methods of sampling.—Swedes have been sampled with the auger, the cores being taken right through the centre of the swede. For sampling swedes in bulk, 100 roots have been selected to represent the entire lot, cored, and the cores dried in two lots of 50. As a rule the two lots gave similar results, in which case they have been averaged; where the divergence was great the samples have been rejected altogether. The work of the past season has tended to confirm the opinion that 25 swedes is the very smallest number that can properly represent an entire crop, and that cores right through the centre afford the cleanest and most satisfactory way of sampling the actual roots selected.

Potatoes have been sliced for sampling as boring has not proved successful. The distribution of dry matter is very irregular in the potato and an auger of convenient size gives borings of too great a diameter in proportion to their length to give a fair sample.

EXPERIMENTAL WORK.

The quality of swedes.—A large number of swedes have been sampled this season to find out the difference in composition due to variety, season, soil and district. The work done under this head during the past season is in continuation of that done in former years and published in the Annual Report for 1901 (pages 96 and 143). The chief difference between the work carried out this season and that of former seasons is that the question of the effect of manures on the composition of swedes has been assumed to be small, as was, on the average, shown to be the case on page 104 of the Report quoted; at certain places, however, the difference in composition due to manures appears important. If any error occurs from neglecting the effect of manures that error will appear in the differences in composition due to the farm on which grown and not in the differences due to variety.

The effect of size was discussed in the Report for 1900 (page 180), small roots being richer than large roots; the difference was important but not so great as those discussed here. It may not be amiss here to point out that the effect of size on the composition of swedes is not so all-important as is popularly supposed. Of the swedes grown and tested during the three years, 1900 to 1902, the smallest and poorest swedes were those of 1901, whilst the largest and richest were those of 1902. The difference in size produced its effect, no doubt, but it was completely overwhelmed by the much greater effect of season. By selecting roots of medium size and discarding the very large and very small ones, samples have been obtained in which the disturbing influence of size is still smaller.

The effect of variety, season and district or farm involved as much work as it was possible to undertake in one year. The other causes of difference in composition will be studied later, as time permits.

The names given to varieties are of course purely fanciful. It is possible that one variety is called by more than one name, but it is improbable that two varieties are ever called by only one name; except, perhaps, where one stock of seed has been grown so long at different centres that each centre produces a variety of its own, the varieties so produced never having been re-named.

High-class seedsmen are constantly selecting their seed and consequently the varieties may slowly change their characters; there is no indication, however, that this change has occurred during the three years in which these experiments have been carried out.

The search for the "best swede."—As was stated in the article on this subject in last season's Report (page 96), "A good variety of swede must not merely be a good cropper but must have as little useless water and as much valuable food material as possible." The hope was expressed that it might be possible to find out certain varieties that were distinctly superior to certain others. This has now been done so far as the varieties selected go, the constant superiority of some varieties to others being proved to a degree of accuracy scarcely expected.

TABLE XXI.—GENERAL RESULTS OF THE AMOUNT OF DRY MATTER IN SWEDES, EXPRESSED IN PER CENT.

	1900.	1901.	1902.												
	Cockle Park.	Cockle Park.	Cockle Park.	Portrack Grange, Stockton.	Kelloe Hall, Coxhoe.	Neasham Grange, Darlington.	Sherburn Colliery.	Grange Hill, Bishop Auckland.	Riffington, Cornhill-on-Tweed.	Red Barns, Bishop Auckland.	Cleatham, Staindrop.	Raby, Staindrop.	Eshott, Felton.	Billingham, Stockton.	Cockle Park.
Crimson King	11·48	10·47	11·57	...	...	11·64	11·54	11·76	12·37	...	...	...	...	...	...
Best of All	10·88	9·63	12·13	...	12·06	11·30	...	..	...	12·27	12·33	...	...	12·92	11·55
Stirling Castle	11·37	10·58	11·85	11·78	...	...	...	12·75	...	...	...	12·73	13·30	...	...
XL All	10·47	9·92	11·23	...	...	11·77	12·18	...	12·04	...	11·90	12·36	...	...	11·58
Fell's Bronze Top ...	12·38	10·41	12·48	12·03	...	...	...	13·19	...	...	...	...	14·09	...	...
Arctic	11·77	10·87	12·39	...	12·62	...	...	12·02	...	12·79	...	...	...	13·62	12·22
Kangaroo	11·73	10·38	11·84	...	...	12·65	11·60	12·25	13·66	...	...	...	...	...	...
Prize Winner	...	11·03	11·72	...	12·07	...	...	12·25	...	12·49	...	...	...	13·20	...
Darlington Swede ...	...	10·18	11·87	11·10	...	...	...	11·48	...	...	12·35	12·70	12·56	...	...

The experiments conducted during the past season under this head divide themselves into two classes, those experiments carried out at Cockle Park and those at different centres in the counties of Northumberland and Durham. All these results have been placed together in Table XXI.: they will be discussed in detail by sections.

Cockle Park experiments: "dry matter."—As has been shown in the former Report the order of merit of the different varieties appears to be approximately constant. Owing to the accumulation of figures on this subject it is scarcely possible to discuss them in the simple manner adopted in the former Report. Without attempting to enter into the details of the method of obtaining averages it will suffice to say that the very severest test that could be applied to the theory, that the difference in the composition of the different varieties is constant, is to calculate out what those differences are; then, with the data so obtained, to calculate what the composition of swedes grown at Cockle Park ought to be according to the theory, and to compare the results so obtained with the results of actual analysis. If the results agree, then not only is the theory correct; but the amounts credited to the causes of the variations must be at least approximately correct also.

Seven different varieties have now been grown at Cockle Park for three successive seasons; the results of which, when averaged, give the figure 11·23 as the composition of an average swede in an average season. From this we find that the differences in composition due to *season* at Cockle Park are

1900	+ ·20
1901	– ·91
1902	+ ·70

By further averaging results we find that the differences in composition due to *variety* are

Crimson King	– ·06	Arctic	+ ·45
Best of All	– ·37	Kangaroo	+ ·09
Stirling Castle	+ ·04	Prize Winner	+ ·25
XL All	– ·69	Darlington Swede	– ·10
Fell's Bronze Top	+ ·53		

From the data so obtained we are now in a position to calculate what the composition of the swedes grown at Cockle Park ought to be according to theory and to compare the results so obtained with the amounts found by direct chemical analysis. If the two sets of figures so obtained agree well with one another, then the theory must be correct and the difference between one variety and another must be constant and independent of season. But what is a good agreement? If the two sets of figures "calculated" and "found" agree with one another as well as the duplicates of the actual analyses did, then the agreement is certainly a good one. I find that the average difference between duplicates of the 71 samples analysed this season is ·31; for the sake of round numbers we can take ·30 as the limit of good agreement. Of the 28 samples of swedes grown at Cockle Park and analysed (page 100) there were 7 samples in which the difference between the duplicates exceeded the amount of ·30; on comparing the "calculated" and "found" amounts as given in Table XXII., it will be seen that the "calculated" amounts differ from the "found" amounts by more than ·30 on only 7 occasions out of the 28. The agreement between "calculated" and "found" amounts is, therefore, a very good one. The Table of relative order of merit at Cockle Park is as follows:—

Fell's Bronze Top	+	·53	the two richest varieties.
Artic	+	·45	
Prize Winner	+	·25	this figure requires a further season's trial.
Kangaroo	+	·09	medium varieties.
Stirling Castle	+	·04	
Crimson King	–	·06	
Darlington Swede	–	·10	this figures requires a third season's trial.
Best of All	–	·37	the two poorest varieties.
XL All	–	·69	

TABLE XXII.—SHOWING AGREEMENT BETWEEN THE CALCULATED AND FOUND AMOUNTS OF DRY MATTER IN SWEDES GROWN AT COCKLE PARK.

	1900.		1901.		1902.		
	Calc	Found.	Calc.	Found.	Calc.	Found.	
	%	%	%	%	%	%	%
Crimson King	11·37	11·48	10·26	10·47	11·87	11·57	...
Best of All	11·06	10·83	9·95	9·63	11·56	12·13	11·55
Stirling Castle	11·47	11·37	10·36	10·58	11·97	11·85	...
XL All	10·74	10·47	9·63	9·92	11·24	11·23	11·58
Fell's Bronze Top ...	11·96	12·38	10·85	10·41	12·46	12·48	...
Arctic	11·88	11·77	10·77	10·87	12·38	12·39	12·22
Kangaroo	11·52	11·73	10·41	10·38	12·02	11·84	...
Prize Winner	...	...	10·57	11·03	12·15	11·72	...
Darlington Swede ...	...	...	10·22	10·18	11·83	11·87	...

To decide which is the best swede requires not only a knowledge of the feeding value of the swede but also a knowledge of the amount of crop, the liking of cattle for it, the manner in which it keeps and many other practical considerations, many of which the practical man already knows, or, if he does not, can obtain the necessary information by simple practical experiments on his own land.*

By means of Table XXIV. farmers will be able to judge for themselves whether the slightly smaller yield of Fell's Bronze Top does or does not overcome the better feeding value, whether the liking of the cattle for the sweet tasting XL All is any sufficient reason for preferring it to the higher feeding value of most of the other varieties, and other similar questions that will arise when the Table is put to practical use.

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* Farmers desirous of instituting experiments on their own land should, communicate with the Professor of Agriculture, Durham College of Science.

The relationship between per cent. of dry matter and feeding value is shown in the sheep feeding experiment in the Cockle Park Report for 1902.

County experiments: "dry matter."—The relative order of merit of the different varieties of swedes being constant at Cockle Park, it remains to be seen whether this order remains the same at other places in the Northern Counties. For this purpose several farmers in the counties of Northumberland and Durham were asked if they would co-operate with the College in investigating this matter and, with their kind help, a "quality experiment" was instituted by the following:—Mr. J. W. Fell, Portrack Grange, Stockton; Mr. Thomas Gibson, Kelloe Hall, Coxhoe; Mr. R. Humphrey, Neasham Grange, Darlington; Mr. R. Wearmouth, Sherburn Colliery, Durham; Mr. H. G. Burkitt, Grange Hill, Bishop Auckland; Mr. W. Waugh, Riffington, Cornhill-on-Tweed; Mr. J. Greenwell, Red Barns, Bishop Auckland; Mr. R. Chandler, Cleatham, Staindrop; Mr. W. T. Bell, Raby Home Farm, Staindrop; Mr. T. H. Bainbridge, Eshott Home Farm, Felton; and Mr. John Forster, Billingham, Stockton.

The "quality experiments" were carried out at the places named in the same manner as at Cockle Park, the seed being all bought at the same time from the same places; each farmer, however, used whatever manure he thought suitable and in some cases a variety of his own was sampled at the same time as those grown for the College. The actual sampling was in all cases undertaken by a representative of the College.

As a general rule the order of merit is much the same as at Cockle Park though there are a few exceptions. The results of the "County" experiments like those of the Cockle Park experiments can best be studied by determining the differences in composition on the assumption that the order of merit is constant. For this purpose we must first calculate what the difference in composition due to the farm is. By taking the average of all the results at each farm, one farm at a time, and comparing the figures so obtained with the averages of the same varieties grown at Cockle Park during the three seasons, a figure is obtained which, after allowing for "season," represents the difference due to the farm. This difference may be due to the soil, the aspect or perhaps the management. The following table gives the figures so obtained. When a + sign occurs it means that at the farm in question the swedes are of better quality than those grown at Cockle Park, a – sign indicates that the swedes of the farm are poorer than those of Cockle Park. Eshott and Billingham grow the swedes of finest quality, whilst Portrack Grange grows the poorest. It is noticeable that Cockle Park is relatively a poorer place for swedes than many other farms in the Northern Counties.

DIFFERENCE IN PERCENTAGE AMOUNT OF DRY MATTER IN SWEDES DUE TO THE FARM ON WHICH GROWN.

Cockle Park...	(standard).
Portrack Grange, Stockton	– ·45
Kelloe Hall, Coxhoe	+ ·21
Neasham Grange, Darlington	+ ·17
Sherburn Colliery, Durham	+ ·06
Grange Hill, Bishop Auckland	+ ·14
Riffington, Cornhill-on-Tweed	+ ·98
Red Barns, Bishop Auckland	+ ·40
Cleatham, Staindrop	+ ·65
Raby, Staindrop	+ ·92
Eshott, Felton	+ 1·23
Billingham, Stockton	+ 1·22

Starting with the fundamental figure, 11·23, which represents the average composition of the swedes of all varieties, in all seasons at Cockle Park, and making the necessary corrections according to the season and variety (page 101) and the

TABLE XXIII.—SHEWING THE AGREEMENT BETWEEN THE CALCULATED AND FOUND AMOUNTS OF DRY MATTER PER CENT. IN THE SWEDES GROWN AT THE PLACES NAMED.

Name of variety.	Portrack Grange.		Kelloe Hall.		Neasham Grange.		Sherburn.		Grange Hill.		Cornbill-on-Tweed.		Red Barns.		Cleatham.		Raby.		Eshott.		Billingham.	
	Calcu-lated.	Found.	Calcu-lated.	Found	Calcu-lated.	Found.	Calcu-lated.	Found.	Calcu-lated.	Found.	Calcu-lated.	Found.	Calcu-lated.	Found.	Calcu-lated.	Found.	Calcu-lated.	Found.	Calcu-lated.	Found.	Calcu-lated.	Found.
Crimson King	..	..	..	..	12·04	11·64	11·93	11·54	12·01	11·76	12·85	12·37	..	..	..	..	..	..	..	..	..	..
Best of All . ..	..	..	11·77	12·06	11·73	11·30	..	..	..	..	..	..	12·04	12·27	12·21	12·33	..	..	..	..	12·78	12·92
Stirling Castle ..	11·52	11·78	..	..	..	..	..	..	12·11	12·75	..	..	..	..	..	..	12·89	12·73	13·20	13·30	..	..
XL All	..	..	..	..	11·41	11·77	11·30	12·18	..	..	12·22	12·04	..	..	11·89	11·90	12·16	12·36	..	..	..	..
Fell's Bronze Top	12·01	12·03	..	..	..	..	..	..	12·60	13·19	..	..	..	..	..	..	..	..	13·69	14·09	..	..
Arctic	..	..	12·59	12·62	..	..	..	..	12·52	12·02	..	.	12·86	12·79	..	.	..	..	..	..	13·60	13·62
Kangaroo	..	..	..	..	12·19	12·65	12·08	11·60	12·16	12·25	13·00	13·66	..	..	..	.	..	..	..	..	..	..
Prize Winner ..	..	..	12·39	12·07	..	..	..	..	12·32	12·25	..	..	12·66	12·49	..	..	..	..	..	..	13·37	13·20
Darlington Swede	11·38	11·10	..	..	..	..	..	..	11·97	11·48	..	..	..	..	12·48	12·35	12·75	12·70	13·06	12·56	..	..

farm at which grown, we can calculate what the composition of the swedes should be according to theory and compare the results with those obtained by direct analysis. As before if the agreement is good then the theory must be correct. The results of this calculation are given in Table XXIII. together with the actual figures of analysis.

Taking as before those results which are not more than ·30 apart to be in good agreement and the rest to be in bad agreement we find that at Portrack Grange, Red Barns, Cleatham, Raby and Billingham all the results are in good agreement, that is 5 farms in 11 produce swedes exactly in the same order of merit and with the same differences as at Cockle Park. Putting all the farms together we see that out of 38 analyses of swedes there are 16 where the differences between the "calculated" and "found" amounts exceed the limit of ·30, whilst in the same analyses the differences between duplicates exceed that limit on 18 occasions. The agreement between the "calculated" and "found" figures is, therefore, as good as could be. It will be noticed that the proportion of *duplicates* which fall within the limit of "good agreement" is greater at Cockle Park than at the various farms at which the swedes were grown. This is probably due to the fact that the land selected at Cockle Park is more uniform and, therefore, gives more uniform results.

It may be well to point out that the Table of differences due to variety is obtained exclusively from the Cockle Park figures, yet when applied to the swedes grown at other places it is at least approximately true for them as well.

It is established, therefore, that the Table of differences due to variety (page 112) is at least approximately correct for many of the farms in the North of England.* There may be certain places where this Table will not be correct, for example at Sherburn the variety XL All has done much better than at Cockle Park, proving, indeed, as much as ·88 per cent. higher than the figure calculated from the Cockle Park results; at Neasham Grange the same variety is also better by the amount ·36 per cent. This latter case is not a large divergence and at Cornhill-on-Tweed, Cleatham and Raby the "calculated" and "found" amounts are in good agreement. There is, therefore, only one serious divergence between the figures for XL All, which may indicate that there are farms in the North of England which do not agree with the rule or it may be merely due to irregularity of soil or other error. Other important divergencies are Stirling Castle, grown at Grange Hill, which is ·64 per cent. above theory; Kangaroo, at Cornhill-on-Tweed, which is ·66 per cent. above theory; Fell's Bronze Top, at Grange Hill, which is ·59 above theory.

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* Similar results have been obtained in Norfolk.

These figures do not convey much information unless there is something to compare them with. It will be noticed that the extreme difference due to variety is 1·22 per cent., to season 1·61 per cent. and to farm 1·68 per cent. In proportion to these figures the exceptional divergencies named above are not sufficient to discredit the general conclusion that the order of merit of the varieties of swedes is practically a fixed one, though the actual figures as deduced from Cockle Park may require a certain amount of amendment (see Table XXIV., page 112).

As is usual in the careful collection of statistics of this kind, the search for one thing leads to the suggestion of many others. The difference due to the different farms is certainly very striking. For example the "average" swede at Portrack Grange would have a composition of 10·78 per cent. of dry matter whilst at Eshott it would have 12·46 per cent. If these figures have anything approaching the constancy of those relating to varieties the margin of profit at the two farms must be very different. That the feeding value of swedes follows the same order as the amount of "dry matter" is shown in the feeding experiments at Cockle Park (see page 111), that these values for the superiority of one farm over another are constant can only be satisfactorily settled by a further trial for one or two years more.

Past records.—There are a few other figures in the report for last season which are capable of being compared with the calculated values. These are as follows:—

Darlington swede,	New Raby Farm,	1901,	"calculated"	11·14 %
			"found"	11·02 %
Best of All,	,, ,,	,,	"calculated"	10·87 %
			"found"	11·23 %
XL All,	,, ,,	,,	"calculated"	10·55 %
			"found"	10·44 %
Best of All,	Neasham Grange,	,,	"calculated"	10·12 %
			"found"	10·55 %
,, ,,	Cleatlam,	,,	"calculated"	10·60 %
	,,	,,	"found"	10·85 %

The agreement between these figures is all the more striking when it is remembered that the values of the varieties used in calculating the above figures were derived from the Cockle Park experiments only, that the correction for season was also derived exclusively from Cockle Park and the correction for the farm was derived from the experiments of 1902 and not from 1901. The results of five analyses are not sufficient to draw final conclusions from, but so far as they go they support the view that the differences in the composition of swedes due to the season and the farm are as fixed as the differences due to variety.

The farm factor and phosphates.—As mentioned above the differences in the amount of "dry matter" between swedes of the same variety grown at different farms may be due to the soil, to the aspect and local climate or to the management. Probably all these causes exert their own influence, but it may easily happen that there is one cause more potent than the others. At present the experiments have not gone far enough to make a thorough study of this subject but so far as one can judge from the present data there appears to be a distinct relationship between the " farm factor " and the way in which the soil responds to applications of phosphatic manures.

In the accompanying table I have placed in the first column the names of those farms of which I have the farm factor (see page 105) and the results of field experiments which show the yield per acre of swedes grown with and without phosphatic manures. In the second column I have placed the amount of extra crop obtained by using the phosphatic manures, and in the third column the " farm factor." Portrack Grange, which is most susceptible to the influence of phosphates, is also the farm which gives swedes of the poorest quality; Riffington, the least susceptible, gives swedes of the richest quality, and the other farms stand intermediate under

THE COMPARISON BETWEEN THE RELATIVE FEEDING VALUE OF SWEDES GROWN AT DIFFERENT FARMS AND THE RELATIVE NEED FOR PHOSPHATIC MANURES AT THOSE FARMS.

Name of farm.	Extra crop by using phosphates in the manure.		Extra amount of dry matter in Swedes.
	Tons.	Cwt.	
Portrack Grange	*12	2	— ·45
Neasham Grange	†10	17½	+ ·17
Cleatham	†9	14½	+ ·65
Kelloe Hall	*9	10¾	+ ·21
Sherburn Colliery	*4	10	+ ·06
Do. do.	†2	13½	
Cockle Park	*2	18½	0
Riffington	*0	0	+ ·98

* See pages 70 and 73.

† See Annual Report, 1901, p. 127.

both heads. That is to say that as far as we can judge at present, from scanty information, it appears that the superiority of the swedes grown at one farm, as compared with another, is largely due to the nature of the soil, though, no doubt, the other causes named above are not without influence.

Home grown varieties.—In a foot note on page 108 of the Report for 1901, the suggestion was made that farmers might do a great deal towards improving the varieties of swedes that they grow.

This season I obtained a sample of swedes from Mr. Greenwell, of Red Barns, which were grown from seed selected on his farm for a great number of years. The analysis showed 12·68 per cent. of dry matter, very nearly as high as the "Arctic" which had 12·79 per cent. of dry matter. That is to say that the home grown seed produced swedes well above the average quality of swedes grown from purchased seeds though not quite equal to those from the very best kinds of seeds on the market.

Feeding experiments.—In connection with these experiments on the amount of "dry matter" in swedes an experiment on the feeding value when fed to sheep has been carried out at Cockle Park, details of which will be contained in the Cockle Park Report for this year. It may, however, be pointed out here that the amount of dry matter in the XL All swedes and the Best of All swedes is so little different that it may be neglected; the feeding trials also show little difference between these two swedes, the Best of All doing better in the first period and worse in the second period. The XL All and Best of All are sweeter than the Arctic swedes, so that it does not appear as if the sugar could have had any great superiority over the other constituents, but simply that the feeding value depended upon the total amount of dry matter only.* We can therefore average the results of the XL All and the Best of All and compare the mean with the results of the Arctic.

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* The actual percentage of sugar was—Arctic, 6·62; Best of All, 6·86; XL All, 6·81.

From this we see that although the actual weights of swedes were the same, the sheep receiving the Arctic swedes got ·74 ℔ of "dry matter" per sheep per week more than the others, producing from this extra food ·68 ℔ of live weight increase in the first period. In the second period they received ·55 ℔ of extra dry matter and produced ·38 ℔ of extra live weight increase. As the total weights of the swedes were the same in both cases the sheep which received ·74 ℔ more "dry matter"

TABLE XXIV.—RELATIVE COMPOSITION OF DIFFERENT VARIETIES OF SWEDES, CALCULATED FROM THE ANALYSES OF 7,400 SWEDES, 1899-1902.

"Standard" Swede	11·23	%	dry matter
Carter's Kangaroo	+ ·16	„	„
„ Elephant	+ ·44	„	„
„ Prize Winner	+ ·16	„	„
Drummond's Stirling Castle	+ ·12	„	„
„ Extra Improved	− ·17	„	„
Fell's Bronze Top	+ ·64	„	„
Garton's Model	− ·82	„	„
Kent & Bryden's Monarch	− ·24	„	„
„ „ XL All	− ·58	„	„
„ „ Darlington Swede	− ·25	„	„
Sutton's Crimson King	− ·21	„	„
Tait's Best of All	− ·34	„	„
Webb's Arctic	+ ·40	„	„

In the above table all available analyses have been incorporated, the figures consequently differ to an immaterial extent from those derived from Cockle Park analyses only (page 102).

must have received ·74 ℔ less water. Not only is this water useless but it has to be warmed up to the body temperature and excreted, both of which operations are a tax upon the food consumed. The actual benefit to the animal of being fed on swedes with a greater proportion of dry matter is consequently greater than the amount of dry matter would at first suggest, as has proved to be the case in the actual feeding trials.

General conclusions :—

(1) The feeding value of swedes increases with the amount of dry matter present (page 111).
(2) Swedes differ very much in the amount of dry matter they contain.
(3) The greatest of all causes of this difference is the individual root (see Report, 1900, p. 180).
(4) The second greatest causes of the difference are variety (page 102), season (page 101), soil (page 109).
(5) The best varieties at one farm are also the best at other farms (page 106).

Mangels.—The study of the chemical composition of mangels grown under different conditions has been begun this year on somewhat the same lines as the corresponding investigations on swedes. Owing to the large amount of work still going on in the matter of the composition of swedes, it has only been possible to make a very modest beginning to this important subject.

Although the mangels have as a whole shown a greater proportion of dry food material than the swedes have, the difference is not a great one and there are many cases where the mangels have had a much lower proportion.

The figures in the accompanying Table are arranged on the same plan as the corresponding Table showing the variation in the composition of swedes due to manures, given in the Annual Report for 1901 (page 104).

TABLE XXV.—MANGELS.

VARIATION IN COMPOSITION DUE TO MANURE.

Station.	Dry Matter (per cent.).					
	Manures.				No manure.	Average.
	Dung and complete artificials.	Nitrogenous artificials omitted.	Phosphatic artificials omitted.	Potassic artificials omitted.		
Little Stainton (Darlington Globe)	13·99	14·58	13·94	14·15	15·47	14·43
Lanchester (Yellow Globe) ...	12·91	13·02	12·76	12·42	—	—
Hurworth-on-Tees (Yellow Globe)	13·01	13·65	12·10	12·73	14·10	13·10
Gainford (Kent & Bryden's Yellow Globe)	13·35	13·84	13·08	13·55	13·92	13·55
Average excluding Lanchester ..	13·45	14·02	13·04	13·48	14·50	13·69

In comparing the results on mangels this season with the results on swedes last season we see that mangels are much more affected by manures than swedes are; that whilst in the case of swedes the differences were small, in the case of mangels the differences are of considerable importance and cannot be neglected. In addition to which, the mangels were manured with farmyard manure in every case, whilst the swedes received no such addition to the artificials. This farmyard manure will contain a fair amount of all the elements of manure and therefore none of the plots tested will have received "no nitrogen," or "no phosphates," or "no potash" in the manure applied. Consequently the test to which the mangels have been subjected is less severe than that to which the swedes were subjected in the corresponding experiments, and we cannot say here as we did in reference to the swedes, that the experiments exaggerate the differences that would occur in practice. On the other hand we must accept the fact that the system of manuring may alter the feeding value of the mangels to a considerable extent.

Considering now the Tables in detail, we see that both in the case of swedes and mangels the "no manure" plot produces roots of the greatest feeding value, that the "nitrogen omitted" plot stands next in order and the "potash omitted" third. The remaining two plots, "phosphates omitted" and "complete artificials" stand in both cases at the bottom of the list though their relative positions are altered.

Considering the results of the mangels alone in detail we see that they are very uniform. Each station agrees with the average of all the stations on the following points:—

(1) The "no manure" plot is the best.
(2) The "nitrogen omitted" plot is the second.
(3) The "phosphates omitted" plot has the lowest feeding value.
(4) The "complete artificials" and "potash omitted" plots are so similar that the differences might be attributed to experimental errors, and are together always in a position between the "phosphates omitted" and the "nitrogen omitted" plots.

This uniformity in the results shows that the manuring has an important influence on the amount of dry food material in the crops grown; it would, however, be better to wait till another season's results have accumulated before coming to any final conclusions on the subject.

In the following Table I have set out the weight of mangels grown per acre and below these figures have placed the calculated yield per acre of dry food material contained in those mangels. The Table is constructed on the same lines as the corresponding Table on swedes given in the Annual

Report for 1901, pages 107 and 145. As mangels are usually grown for cattle feeding, the lower figures giving the weight of food material will more accurately represent the real value of the crop grown, than the gross weight of the crop would.

TABLE XXVI.—MANGELS.

TOTAL CROP AND DRY MATTER IN TOTAL CROP PER ACRE.

Station.	Manures used.				No manure.
	Dung and complete artificials.	Nitrogen of artificials omitted.	Phosphates of artificials omitted.	Potash of artificials omitted.	
	T. C.	T. C.	T. C.	T. C.	T. C.
Little Stainton ...	16 1¾	11 14¾	15 18¾	15 5	9 10¾
	2 5	1 14¼	2 4½	2 3¼	1 9½
Hurworth-on-Tees	13 11¾	9 11¾	15 4	13 14¾	8 15¾
	1 15½	1 6¼	1 16¾	1 14¾	1 4¾
Gainford	23 10	17 9¾	23 1	20 16	16 5
	3 2¾	2 8½	3 0¼	2 16½	2 5¼

Studying the Table in general it will be seen that the upper and lower lines more or less follow one another, that is to say if the gross yield in one plot is greater the calculated yield of dry food is also greater. In the case of Hurworth-on-Tees, the order of the plots manured with "complete artificials" and "potash omitted" is reversed though from neither point of view could the differences be considered of any practical consequence.

At Hurworth-on-Tees the "phosphates omitted" plot gave 1 ton 12¼ cwt. more mangels than the "complete artificials" plot, a good increase, but the amount of dry food material was only 1¼ cwt. in favour of the former plot, a difference which might be attributed to experimental error.

If we compare the two Tables XXV. and XXVI. we shall see that a big yield of mangels corresponds with a low percentage of dry matter in that crop, whilst a small yield corresponds with a high percentage. Consequently, the gross weight tends to exaggerate the differences. Whilst it is true that this relationship holds when comparing the different plots at one station, it is altogether wrong when comparing one station with another. For example the yield of mangels at Gainford was the best of the three stations, but the mangels grown there were not the poorest. Also at Hurworth-on-Tees the yield was the lowest but the percentage of dry matter instead of being the highest of the three stations was actually the lowest.

Potatoes.—The experiments conducted under this head during the season of 1902 are a repetition of those of the former season, the details of which are given on page 109 of the Report for 1901. Of the 15 different systems of manuring tested in 1901, few gave results of much interest except the potash manures. Of these the "no potash plot" produced too small a crop to be of any practical consequence, but the three different kinds of potash manures seemed to produce important differences between the amounts of dry matter in the tubers grown with them.

TABLE XXVII.—AMOUNT OF DRY MATTER IN POTATOES GROWN IN NORTHUMBERLAND AND DURHAM 1902.

Plot	2	6	7	8	9
Manure	Dung.	Complete artificials. Double potash in the form of			Complete artificials.
Name of Farm.		Muriate.	Sulphate.	Kainit.	
Portrack Grange, Stockton ...	22·15	21·62	23·62	21·08	21·08
Headlam Hall, Gainford ...	24·75	24·73	25·78	23·19	23·48
Denton Hall, Piercebridge ...	23·50	23·08	25·77	22·13	25·87
Thornley	22·62	21·60	23·96	20·60	23·01
Murton Junction	20·61	21·56	22·73	20·20	22·94
Broomside Head, Durham ...	22·71	23·36	24·50	24·47	25·82

In Table XXVII. I have placed on record the amounts of dry matter in the potatoes grown with 5 different systems of manurial treatment. In the first column is given the name of the farm at which the tubers were grown, in the second column, plot 2, is given the amount of dry matter in the potatoes grown with dung alone and in the last column, plot 9, is given the amounts of dry matter in the potatoes grown with a complete dressing of artificials, details of which are to be found on page 82 of this Report. In the three middle columns are given the amounts for the three potash manures in the same way.

The results of the two seasons are in perfect accord, the potash in the form of sulphate having produced potatoes with a greater amount of dry matter in them than those grown with either of the other forms of potash manures, whilst the potatoes grown with the potash in the form of kainit are the wettest.

As in the former season the results of the other manures do not seem to convey any useful lessons.

Milk.—A few preliminary investigations have been made under this head in order to find out what the composition of the ordinary milk in the North of England is when the cows are the ordinary shorthorns popular in the district and the feeding is such as the dairy farmers are accustomed to give. Until we have some more information on this head any actual experiments on feeding would be of little use. At the time of writing this article the evidence at our disposal is not sufficient to base any conclusions on; it is possible to state, however, that we have found several cases of single cows giving results under the standard. It certainly, moreover, appears that it would be possible to discover the worst cows in a herd so far as the standard is concerned, though it is not likely that it would be possible to remove from a herd all the cows that sometimes gave milk below the standard. There are plenty of shorthorns in the herds that we have tested that give milk of a high quality.

COMMERCIAL PRODUCTS.

County experiments: manures.—These include two samples of sulph. am. 98·00 and 96·59 per cent. pure; two samples of nitrate, 98·22 and 97·58 per cent. pure; one super., containing 32·22 per cent. of soluble phosphate; three samples of kainit, 12·13, 13·46 and 12·71 per cent. of potash; a sample of fish meal containing 8·13 per cent. nitrogen and 8·79 per cent. phosphates; and one sample of a phosphatic Peruvian guano, containing 1·88 per cent. nitrogen (2·28 per cent. ammonia) and 67·15 phosphates, the official cargo analysis being 2·32 per cent. ammonia and 66·16 per cent. phosphates.

Experiments on Crops and Stock at Newton Rigg.

(W. T. LAWRENCE.)

These experiments have been carried out at the Cumberland and Westmorland County Council Farm, Newton Rigg, Penrith, during the year ending January 31st, 1903.

Manuring of meadow hay.—The plan followed in the manuring of the six quarter-acre meadow plots has been to dress them every third year with the manures shown in the following table, for the purpose of seeing (1) the effects in the year of application, (2) the residual values in the second and third years, and (3) the comparative values of nitrate and sulph. am., and of basic slag and super.

So far there has been no very great difference in the yields produced by the several dressings in the year of application; but on the whole dung has led; nitrate beat sulph. am. at first, but has not done so since; super. has consistently beaten basic slag; dung has shown three times the residue of the artificials in the second year, but no better residue in the third year.

The year 1902 was a remarkably good one for meadow hay, as the following yields show:—

Plot.	Dressing per acre in 1902.	Cost.	Yield per acre.
		s. d.	Cwt.
1	No manure	—	28
2	10 tons of dung	40 0	50¼
3	¾ cwt. nitrate, 1½ cwt. kainit, and 3 cwt. slag ...	15 10	40½
4	¾ cwt. sulph. am., 1½ cwt. kainit, and 3 cwt. slag ...	17 6	42½
5	¾ cwt. nitrate, 1½ cwt. kainit, and 3 cwt. super. ...	16 11	43¼
6	¾ cwt. sulph. am., 1½ cwt. kainit, and 3 cwt. super.	18 5	43¼

Growth of potatoes.—The three varieties that cropped best in 1901—a record potato year—were planted again in 1902, side by side, manured with 12 tons of dung to the acre. Plots 2 and 3 were manured with artificials only, the dressing given to plot 2 being the one that has proved best in other years. Sulph. potash was substituted for kainit on plot 3, as it is sometimes said that the common salt in kainit somewhat retards the action of its potash. The sulph. potash used was equal in cost to the kainit and contained about the same percentage of potash. This year (1903) mur. potash will be tried side by side with kainit.

TABLE OF RESULTS.

Plot.	Variety.	Manurial dressing per acre.	Cost.	Yield per acre.		
			s.	T.	C.	Q.
1	Farmers' Glory	No manure	—	5	9	3
2	Do.	1½ cwt. nitrate, 1 cwt. sulph. potash, and 4 cwt. super.	36	7	17	0
3	Do.	1½ cwt. nitrate, 4 cwt. kainit, and 4 cwt super.	36	8	16	2
4	Do.	12 tons dung (no artificials) ...	48	10	6	2
5	General French	Do. do.	do.	9	13	2
6	Up-to-date	Do. do.	do.	12	1	1

It certainly does not appear from these results that kainit is here a less effective potash manure than sulph. potash, for it has practically produced a ton more potatoes. Dung has very decidedly beaten the artificial dressings, as it has always done at Newton Rigg in the case of the potato crop; and, as in previous years, Up-to-date still proves to be the heaviest cropping variety.

Growth of mangels.—The results of six years' trials have shown that either (1) 20 tons of dung (half ploughed in and half in the drills), or (2) 3 cwt. nitrate, 2 cwt. kainit and 4 cwt. super., or (3) 12 tons of dung in the drills with a top-dressing after singling of 1½ cwt. of nitrate to the acre, is a highly satisfactory dressing for the mangel crop on the Newton Rigg soil. The trial in 1902 was intended to show whether a mixed artificial dressing of equal cost with the 1½ cwt. of nitrate used in No. 3 dressing would prove equally as effective.

Plot.	Dressing per acre.	Yield per acre.
		Tons.
1	12 tons dung, and 1½ cwt. nitrate	18
2	12 tons dung, 1 cwt. nitrate, 75 lbs. kainit, and 150 lbs. super.	17½

It will be seen that the crop as a whole was a very poor one—barely half of that of 1901—owing to the season; the bulbs being small, while the leaf development was enormous, thus showing that the backward season prevented the maturation of the crop. The test should therefore be repeated in a more favourable season. So far, however, as the past season's results are concerned, there seems to be little to choose between supplementing the dung with nitrate alone and with mixed artificials of a more complete manurial character.

Growth of swedes.—The following table shows the manurial dressings and yields per acre of the seven plots under experiment in 1902:—

Plot.	Manurial dressing.	Cost of artificials.		Yield.	
		s.	d.	T.	c.
1	No manure		...	2	3
2	12 tons dung (no artificials)		...	26	1
3	6 cwt. of super. only	16	6	18	12
4	1 cwt. nitrate, 2 cwt. kainit, and 5 cwt. super. ...	28	0	22	0
5	1 cwt. nitrate, 2 cwt. kainit, and 5 cwt. basic slag	28	0	22	12
6	1 cwt. nitrate, 2 cwt. kainit, 3½ cwt. slag, and 1½ cwt. super	28	0	23	17
7	4 cwt. pure dissolved bones and 2 cwt. kainit ...	28	0	23	3

The past season was one of the best of recent years for the swede crop, and therefore the complete failure of the unmanured plot is the more remarkable. The brairding on this plot was good, but no progress was made after singling. Evidently this field is very deficient in available phosphates. This view is supported by the results obtained on plot 3, where 6 cwt. of super. alone, costing 16s. 6d., have increased the yield by 16½ tons to the acre. The dressings given to plots 4 and 5 are those which have been tried with consistent success on each arable field of the farm; these, and the 12 tons dung applied to plot 2 may each be regarded as a standard turnip manure for this land; in some years, as in the droughty one of 1901, the artificials have beaten the dung; in other years, as in 1902, the dung has beaten the artificials.

The plot 4 dressing containing super., is acid, and on that account tends somewhat to encourage "finger-and-toe," whereas plot 5 dressing is alkaline, through the presence of lime in the basic slag, and therefore tends rather to discourage that disease. In the dressing given to plot 6, basic slag and super. were mixed so as to give a neutral dressing as nearly as possible. Unfortunately for the experiment, there was no "finger-and-toe" in the swede crop this year, so that no comparison is possible between the acid, alkaline, and neutral phosphate relative to this disease; but the neutral dressing produced 1¼ tons more swedes. On plot 7, 4 cwt. of diss. bones took the place of the nitrate and phosphate of the other dressings at the same cost, and did slightly better. Evidently 4 or 5 cwt. of this highly esteemed manure with 2 cwt. of kainit forms an excellent turnip manure without the aid of dung or other fertiliser.

Clovers.—H. Richardson & Co., of York, sent an ounce of each of the following clovers to be sown and reported on. A good plant of clover is of so much value on account of its excellent feeding qualities, its power of enriching the soil in nitrogen through the agency of its microbe-produced root nodules, and its rapid accumulation of root fibre in the soil, that it is of the first importance that farmers should know which seed is likely to do best. This report deals merely with this first year's result; but as much of the value of clover as a constituent of a seeding for temporary or permanent pasture lies in its longevity, the reports of the next few years will be of even greater importance than that of this year.

	Seeds sown.	Appearance 1st year.
Reds.—1.	English single cut cowgrass	Excellent.
2.	English giant hybrid	Excellent.
3.	Chilian	Excellent.
4.	English red	Good.
5.	English cowgrass	Good.
6.	New Zealand	Good.
7.	Canadian	Fair.
8.	Bohemian	Fair.
9.	Styrian	Fair.
10.	Bavarian	Fair.
11.	United States	Poor.
12.	Russian	Poor.
Whites.—1.	Friesland	Excellent.
2.	German	Good.
3.	Russian	Good.
4.	English white	Fair.
5.	Dutch	Fair.
6.	English giant white	Poor.

PLAN OF ROTATION EXPERIMENT.

Plot.	1901. SWEDES.	1902. OATS.	1903. SEEDS HAY.	1904. GRAZED.	1905. OATS.
1	6 tons dung ploughed in, and 6 tons in drills. Crop = 21 tons, 19 cwt. Fed on with sheep.	no manure. crop = 72 cwt.			
2	1 cwt. nitrate, 2 cwt. kainit, 5 cwt. super. Crop = 24 tons, 4 cwt. Fed on with sheep.	no manure. crop = 65½ cwt.			
3	1 cwt. nitrate, 2 cwt. kainit, 5 cwt. super. 24 tons, 1 cwt. All carted off.	½ cwt. nitrate ½ „ kainit 1 „ super. crop = 60¾ cwt.	½ cwt. nitrate 1 „ kainit 2 „ super.		
4	1 cwt. nitrate, 2 cwt. kainit, 5 cwt. super. Crop = 22 tons, 6 cwt. All carted off.	no manure crop 53¼ cwt.			
5	1 cwt. nitrate, 2 cwt. kainit, 5 cwt. basic slag. Crop = 23 tons, 6 cwt. All carted off.	½ cwt. nitrate ½ „ kainit 1 „ slag crop = 63½ cwt.	½ cwt. nitrate 1 „ kainit 2 „ slag		
6	1 cwt. sulph. am., 2 cwt. kainit, 5 cwt. slag. Crop = 21 tons, 15 cwt. All carted off.	½ cwt. sul. am. ½ „ kainit 1 „ slag crop = 64 cwt.	½ cwt. amm. 1 „ kainit 2 „ slag		
7	No manure. Crop = 15 tons, 11 cwt. All carted off.	no manure crop = 60 cwt.			
8	6 tons dung and ½ cwt. nitrate, 1 cwt. kainit, 2½ cwt. super. Crop = 21 tons, 5 cwt. All carted off.	no manure crop = 60½ cwt.	½ cwt. nitrate ½ „ kainit 2 „ super.		
9	12 tons dung in drills. Crop = 22 tons, 10 cwt. All carted off.	no manure crop = 62 cwt.			
10	12 tons dung ploughed in. Crop = 19 tons, 11 cwt. All carted off.	no manure crop = 65¾ cwt.			
11	6 tons dung ploughed in and 6 tons in drills. Crop = 21 tons, 14 cwt. All carted off.	no manure crop—63½ cwt.	6 tons dung		

Rotation experiment.—Second crop—oats. The general scheme of this experiment is shown in the following table, and the results of the first crop (swedes) are given per acre; but, unfortunately, through the almost continuous rain of March this year (1903) the threshing of the oats is delayed beyond the date of writing this report, consequently only the *total* weight of the second crop—oats (straw and corn) is given. The variety grown was Tartar King—a good crop.

Sheep feeding.—On November 21st, 40 cross-bred Border Leicester-Cheviot hoggs were divided into two lots of 20 each

		Lot 1. On swede ground.	Lot 2. On pasture.
1.	Weight at first	1786 lb.	1901 lb.
2.	Gain in 11 weeks	500 lb.	397 lb.
3.	Gain per head per week ...	2·3	1·8
4.	Live weight when killed ...	2286 lb.	2298 lb.
5.	Dressed weight	1165 lb. and 127 lb. fat	1185 lb. and 133 lb. fat
6.	Percentage of dressed to live weight, exclusive of fat	51	51·6
		s. d.	s. d.
7.	Prime cost each	22 6½	23 11½
8.	Selling price net	40 11	41 0
9.	Gross profit per head	18 4½	17 1½
10.	Food consumed per head ...	20 lb. linseed cake	20 lb. linseed cake.
	" " " ...	20 lb. oats.	20 lb. oats.
	" " " ...	26 lb. hay.	24 lb. hay.
	" " " ...	13 cwt. swedes	12½ cwt. swedes.
		s. d.	s. d.
11.	Value of food at present prices	7 7	7 3
12.	Net profit per head	10 9½	9 10½

and weighed. Lot 1 was penned on the swede land to consume half an acre of swedes, while lot 2 was placed on pasture to consume the swedes off half an acre. The acre of swedes weighed 26 tons, and the feeding experiment ended when the first lot had eaten their 13 tons of swedes, which was on February 5th—eleven weeks from the commencement. The other lot had then 1¼ tons of swedes still uneaten. The roots were cut and served to the sheep twice a day; an allowance of ¼ ℔ linseed cake and ¼ ℔ oats was given per sheep per day, and all had hay *ad lib.* On February 5th the sheep were again weighed, and on the 7th were killed, dressed and sold by weight in the London Central Meat Auction Market. The above table gives particulars.

The results fully corroborate those of former years, which have shown that, be the weather wet or dry, hoggs fatten faster on the turnip land than on grass, other conditions being the same. Here line 3 shows that the lighter sheep on the turnip land increased a fraction over 2¼ ℔ each per week in weight, while those on grass only increased a fraction over 1¾ ℔ each, a difference of exactly ½ ℔. It will be seen from the table that the financial results are distinctly in favour of eating off the roots where they are grown.

It should be mentioned that one sheep in lot 2 died soon after the feeding trial commenced, but for purposes of comparison the weight of this sheep has been taken as the average of the other nineteen; also that it was difficult to keep those on grass clear of foot-rot, while those on the swede land showed no symptoms of this complaint.

No account is here taken of the manurial value of the foods consumed.

DEMONSTRATION PLOTS AT NORTH EASTERN COUNTIES SCHOOL, BARNARD CASTLE.

(E. W. READ, M.A.)

Four plots, each $\frac{1}{16}$ acre in area, are worked on the four-course system. In 1902 the crops were: Oats (six varieties), roots (four varieties of mangels and three of swedes), barley (five varieties), and seeds (red clover and Italian ryegrass). The following results are interesting:—

Varieties of oats.	Average number on each of ten panicles.	
	of spikelets.	of grains.
Longhoughton	149	298
Black Tartarian	99	198
Prize White	109	185
Abundance	88	160
Newmarket	60	147
Waverley	61	129

The four varieties of mangels received 12 tons dung, 6 tons rotten silage, 1 cwt. sulph. am., 2 cwt. slag, 2 cwt. super., and 1 cwt. sulph. pot. per acre. The yield of roots varied from 25 to 36 tons an acre, a globe variety giving the best result. The seed for one row of each variety was steeped before sowing, but resulted in no apparent hastening of the growth. The spring frosts of last season encouraged the mangels to "run to seed," long reds being worst in this respect.

The swedes were manured similarly to the mangels, and yielded from 19 to 37 tons an acre of roots.

Ten plots, each $\frac{1}{32}$ acre in area, demonstrate the effects on beans, swedes and barley of omitting one or more of the manurial ingredients from the manure applied. This series of plots proves to be a most interesting object lesson. With no potash beans fail, with no phosphates swedes fail, and with no nitrogen barley suffers severely. Either complete artificials or dung produce equally good results with all the crops.

Maize, sown May 29th, 1902, failed to germinate, whereas the previous season it grew three feet high and stood till October 11th. Thousand-headed kale was transplanted where maize failed, and produced a great bulk of green food, standing till April.

The seed corn for all the plots is "pickled" with Clarke's mixture, and is then saturated with gas tar and water. This renders it safe from birds and does not injure it.

The Agricultural Class has this year acquired a piece of old pasture for the purpose of demonstrating the effects of different combinations of manures suggested by Professor Gilchrist.

The foregoing are the results of general interest for the past season. In addition to work of the above character, the germinating powers of seeds are tested by the boys, and a large number of agricultural plants are grown for demonstration purposes. The soil is a loam resting on Boulder Clay.

The Durham College of Science,

NEWCASTLE-UPON-TYNE.

PRINCIPAL, HENRY PALIN GURNEY, M.A., D.C.L.

Subjects.	**Professors and Lecturers.**
Agriculture, Forestry, Estate Management, Entomology	Professor D. A. Gilchrist, B.Sc., F.R.S.E. C. Bryner Jones, M.R.A.S.E., F.H.A.S. George Potts, B.Sc., Ph.D., N.D.A., F.H.A.S. A. T. Gillanders.
Chemistry	Professor P. Phillips Bedson, M.A., D.Sc., F.I.C., F.C.S. F. C. Garrett, M.Sc., F.C.S. J. A. Smythe, M.Sc., Ph.D. H. W. Cousins, B.Sc.
Agricultural Chemistry	S. H. Collins, F.I.C., F.C.S. A. Short, B.Sc.
Botany and Agricultural Botany	Professor M. C. Potter, M.A., F.L.S. M. Brack, B.A., B.Sc.
Geology & Agricultural Geology	Professor G. A. Lebour, M.A., M.Sc., F.G.S.
Natural History ...	Professor G. S. Brady, M.D., LL.D., D.Sc., F.R.S.
Anatomy, Physiology, and Pathology of Farm Animals ...	A. Meek, M.Sc., F.Z.S.
Mathematics	Professor—The Principal. Assistant Professor C. M. Jessop, M.A. G. W. Caunt, M.A. W. M. Davidson, M.A., M.Sc.
Physics	Professor H. Stroud, M.A., D.Sc., F.Ph.S.L., M.I.E.E. R. J. Patterson, M.Sc. J. W. Bullerwell, M.Sc.
Engineering and Agricultural Engineering	Professor R. L. Weighton, M.A., M.I.N.A. H. R. Cullen, M.A. W. W. Firth, M.Sc.
Surveying	Professor Henry Louis, M.A., A.R.S.M., F.I.C., F.G.S. G. H. Stanley, A.R.S.M.
Building Construction...	J. P. Allen, Prof. Assoc. Sur. Inst.
Horticulture	George Berry.

This list comprises the names of Teachers whose classes are attended by Agricultural Students.
A complete List of the Professors and Lecturers will be found in the College Calendar.

OUNTY COUNCILS OF CUMBERLAND, DURHA
AND NORTHUMBERLAND.

AGRICULTURAL DEPARTMENT

OF THE

RHAM COLLEGE OF SCIENCE, NEWCASTLE-UPON

TWELFTH ANNUAL REPOR
ON
ELD AND OTHER EXPERIME

1903,

COMPILED BY

DOUGLAS A. GILCHRIST, M.Sc., F.R.S.E., F.H.A.S

Professor of Agriculture and Rural Economy.

Principal Contents.

MANURES FOR OLD LAND HAY.
MANURES FOR ROOT CROPS.
VARIATIONS IN COMPOSITION OF MILK.
EXPERIMENTS AT NEWTON RIGG.

LONDON AND NEWCASTLE-UPON-TYNE:
ANDREW REID AND COMPANY, LIMITED, PRINTERS AND PUBLISHERS.
—
1904.

Price 1s.; by post, 1s. 2d.

PREFACE.

This Twelfth Annual Report contains results of the Agricultural Department's experimental and other work throughout Cumberland, Durham, and Northumberland. In future this will be extended to Westmorland. The Cockle Park results are published separately by the Northumberland County Council.

During 1903 Field Experiments were made at 59 centres on a total of 63¼ acres of land, divided into 825 plots.

The composition of the milk (individual and mixed) of five herds of dairy cows, has been investigated during 1903. An account of this work has already been given to the Northumberland and Durham Dairy Farmers' Association, but the tabulated results are now published for the first time. Further similar investigations, and feeding experiments with dairy stock, are being made at Offerton Hall, the Durham County Council Dairy Research Station.

The Agricultural Department has during the year answered a large number of inquiries on all branches of agricultural science, and invites further inquiries from North of England agriculturists as to the results of the College field experiments, the manuring of arable and pasture land, diseases of crops, and insect and other pests.

The old land hay manurial trials continue to show that the underlying rock from which the soil is formed may very considerably influence the manurial requirements of the soil. The trials on root crops for one year, however, rather indicate that previous manurial treatment may considerably alter the natural requirements of the soil, but when the tests are made over complete rotations of crops, the natural deficiencies again become evident.

The results of a full inquiry into the composition of many varieties of swedes, and of feeding experiments with these, are being published in the Cockle Park Report.

In calculating the cost of the different systems of manuring the following prices per ton, being those of last spring (1904), have been taken:—Nitrate of soda, £9 15s.; sulphate of ammonia, £13; superphosphate (26 per cent.), £2 10s.; kainit, £2 5s.; muriate of potash (50 per cent. potash), £8 15s.; slag (37 per cent. phosphates), £2 7s. 6d.; bone meal, £5 10s.; dissolved bones, £5 10s.; fish meal, £6 10s.; sulphate of potash (50 per cent. potash), £10; precipitated bone phosphates, £6; lime shells, 12s. 6d.; ground lime, £1 2s. 6d.; salt, £1; dung, 5s.

The publication of the following results is reserved till later:—

Rotation experiments: Mr. J. Knox Lyal, Peepy, Stocksfield; Mr. John Angus, Whitefield, Morpeth; Mr. George Liddell, Kimblesworth Grange, Chester-le-Street; and Mr. R. Tinniswood, Rose Bank, Dalston.

Meadow hay experiments: Mr. T. Robinson, Shield Ash, Stanhope; The Durham County Council, Earl's House, Durham; Mr. H. G. Coates, Howe Hills, Ferryhill; Mr. John Willan, Shincliffe, Durham; Mr. J. Vickers, Elm Park, Tow Law; and Mr. Thos. Cleasby, Broomside House, Durham.

Pasture experiment (manuring and seeding): Mr. Anthony Wilkinson, J.P., D.L., Pike Whins, Hurworth Burn.

Cabbages: The Durham County Council, Earl's House, Durham.

Demonstration plots: The North-Eastern Counties School, Barnard Castle.

Varieties of swedes and mangels: Mrs. Potts, Whitehurworth, Trimdon Colliery, R.S.O.; Mr. T. W. Stephenson, Denton Grange West, Heighington; Mr. J. W. Fell, Portrack Grange, Stockton; The Right Hon. Lord Barnard, Raby Home Farm, Staindrop (New Raby); Mr. T. H. Bainbridge, Eshott Home Farm, Felton; and Mr. R. Wearmouth, Sherburn Colliery, Durham.

Varieties of wheat: Mr. John Swann, Lookout Farm, Seaton Delaval, R.S.O.

Mr. Bryner Jones is mainly responsible for, and has written the section of this Report dealing with the manuring of swedes, potatoes and mangels. Dr. Potts is responsible for the despatch of the manures, has in many cases supervised their application and the weighing of the produce, and has assisted in preparing the results for publication. All the analytical work involved has been carried out by Mr. S. H. Collins. Mr. Lawrence again writes an account of the experimental work at Newton Rigg, the Cumberland and Westmorland Farm School.

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Manurial Experiments on Pasture and on Old Land Hay.

Now that the College experiments have been continued for over nine years at eight centres on old land hay in Cumberland, for over eleven years on old land hay at Broomhaugh, and for over seven years on poor stiff pasture at Cockle Park, it is safe to draw certain conclusions from their results.

MANURES FOR PASTURE.

Tree Field.—This experiment at Cockle Park has shown that a poor clay pasture lying on Boulder Clay can be most profitably improved by a heavy dressing (10 cwt.) of basic slag of good quality. There are already indications on Cockle Park and at other centres in the North of England that a second dressing of slag will maintain and develop this improvement, and there are also indications that the feeding of cake to the grazing stock will effectually assist slag in doing so. For this purpose undecorticated cotton cake (rough Indian—Bombay—cotton cake), owing to its low price and high manurial value, has proved very effective at Cockle Park. Basic slag will not act by itself on the more sandy soils lying under old pasture, but when assisted by a potash manure it has given excellent results on such soils at Cockle Park, and on old land hay at Broomhaugh. Superphosphate has given good results on both these classes of soils, but it is not as profitable as basic slag.

Sulphate of ammonia added to basic slag has very considerably reduced the good effects of superphosphate in Tree Field, while on old land hay at Broomhaugh the same manure does very great harm when added to basic slag and a potash manure. At this centre nitrate of soda also does harm in this way, but not to the same extent.

On the Hanging Leaves fields at Cockle Park an important experiment is now in progress with the object of ascertaining how the improvement of poor clay pasture commenced by basic slag can be best maintained and developed.

The following suggestions are based on the results up to the present:—

1. There are very large areas of poor pasture in the North of England lying on Boulder Clay. A great deal of this land can be effectively improved by a dressing of 7 to 10 cwt. an acre of basic slag followed up by the regular feeding of cake to the grazing stock.
2. There are considerable areas of lighter soil in pasture lying on the sandstone rocks of the Mountain Limestone and the Millstone Grit, and on other formations which are poor in lime, and these probably could be effectually improved by the same treatment as for the foregoing, with the addition of say 2 cwt. of muriate of potash per acre to the basic slag.
3. On soils which have limestone as the underlying rock, light dressings of superphosphate will probably be more useful than basic slag, while the feeding of cake will also be useful unless the herbage is of a rank character, in which case this latter should be avoided.
4. Moderate or heavy dressings of lime are not likely to be profitable except in the case of peaty or otherwise sour land, on which the herbage is of a rank nature. A light dressing of ground lime (½ ton an acre) in conjunction with superphosphate has done well in Tree Field.

5. Farmyard manure is very useful on thin pasture soils recently laid down and greatly promotes the formation of a sward on such land, but it will not give so good results on old turf of a matty character, nor on soils which have a great deal of peaty or organic matter.

MANURES FOR OLD LAND HAY.

Effects of adding nitrate of soda and sulphate of ammonia to phosphatic and potash manures.—At Broomhaugh basic slag and kainit has given an average annual profit of 13s. 11d. per acre for eleven years, but when nitrate of soda was added to these manures this annual profit was reduced to 13s. 6d. an acre, and when sulphate of ammonia was similarly used there was actually a loss of 3s. 4d. an acre. At Blencow, Glasson, Castle Carrock, and Eskdale the average annual profit per acre at each of these centres was as nearly as possible on the average reduced by 3s. 6d. for nine years when nitrate of soda has been added to a dressing of superphosphate and potash manure. At the same four centres, when sulphate of ammonia was compared with nitrate of soda in a complete manure the nitrate had 8s. 2d. an acre annually in its favour at Blencow (clay loam), 2s. 6d. at Glasson (peat), 3s. 1d. at Castle Carrock (alluvial), and 14s. 3d. at Eskdale (loam on granite).

The foregoing figures raise the very important question as to whether these nitrogenous manures should be used at all on old land hay, and show the worse effects of sulphate of ammonia than of nitrate of soda for this purpose. Based as they are on long continued experiments, they deserve the closest attention of those who are growing old land hay year after year on the same land and are manuring with artificial manures. The foregoing values are based simply on the amount of hay produced per acre, but undoubtedly the value of the hay per ton is much greater when nitrogenous manures are not used, as has been shown by the Palace Leas meadow hay experiment at Cockle Park, so that the figures given above do not represent the full disadvantage of using nitrogenous manures.

Effects of basic slag and superphosphate.—Over a series of years frequent small dressings of basic slag only have not been profitable on the sandy soil at Broomhaugh, on the peat at Glasson, on the alluvial soil at Castle Carrock, nor on the high-lying loam at Eskdale; but at Shield Ash, Weardale, 5 cwt. of basic slag per acre has given an annual profit of 17s. 6d. on a loam soil lying on a sandstone of the Mountain Limestone. It is therefore only on exceptional soils that basic slag alone is profitably applied year after year for old land hay. Superphosphate only has given an average annual profit of nearly 5s. an acre at Glasson and at Eskdale, but generally speaking it has not done well when applied alone. When applied in conjunction with nitrate of soda and a potash manure, basic slag gave the best result on the sandy soil at Broomhaugh, on the peat soil at Glasson, and on the clay soils at Wigton and Kirkbampton, while it also gave slightly the best result on the alluvial soil at Castle Carrock; but on the other hand superphosphate (also in conjunction with nitrate of soda and a potash manure) did rather better on the loam at Eskdale, the sandy loam at Brampton, and on the light alluvial soil at Gosforth. There is therefore a considerable balance of advantage in favour of basic slag. Basic slag is evidently preferable for clay and peaty soils, while on the lighter class of soils no definite rule can be laid down. When, however, lime is abundant in the soil, superphosphate will probably be the more effective.

Effects of potash manures.—A study of the results at the various centres where the presence or absence of a potash manure can be compared shows that the annual gain per acre is decreased by withholding the potash manure as follows:—

On the sandy soil at Broomhaugh, over 14s. an acre; on the oam on granite at Eskdale, about 15s.; on the alluvial soil at Castle Carrock, 10s. 6d.; and at Shield Ash, on sandy loam, about 6s. 6d.; but, on the other hand, its use has been about 2s. an acre less profitable on the peat soil at Glasson. On the heavy soil of the Palace Leas at Cockle Park, the addition of potash has been distinctly profitable when the quality of the hay is taken into account. Generally, therefore, the use of potash manures is advisable for old land hay, and is essential on the lighter class of soils. Of course, when dung is used it will to a certain extent supply the potash requirement.

Complex mixtures.—One of the principal objects kept in view in carrying out Set II. of the Cumberland hay centres has been to test the value of a complex mixture of manures for meadow hay. The most complex dressing is that applied to plot 14, which supplies nitrogen from four sources, viz., nitrate of soda, dissolved bones, bone meal and fish meal; phosphates from five sources, viz., superphosphate, slag, dissolved bones, bone meal and fish meal; and potash in kainit and fish meal. This mixture constitutes one-fifth of the collective dressings given to five other plots, each of which receive their nitrogen and phosphates in only one manure. When contrasted with these five plots the superiority of the complex mixture (see Table IV., p. 25) is at once obvious; as, on the average, this plot has given considerably the largest profit, which at three of the four centres amounted to over 14s. per acre.

Effects of dung.—Ten tons of dung each alternate year has been very unprofitable either by itself, or in addition to artificials, on the peat soil at Glasson and on the clay loam at Blencow. It has, however, on the average been profitable on the alluvial sandy soil at Castle Carrock and on the loam on granite at Eskdale, although not so much so at these centres as certain of the artificial dressings. On the poor sandy soil at Broomhaugh, 10 tons of dung in each alternate year has given an annual profit of about 12s. an acre. On the sandy loam at Shield Ash 10 tons of dung each alternate year has given only a small profit; but, when either slag or a complex dressing of artificials was used with the dung, the results were excellent. It will therefore be seen that dung is not profitable for old land hay on peat soils, nor as a rule on the heavier class of soils, but that its judicious use is likely to be so on the lighter soils.

Effects of lime.—The effects of lime have been tested at four centres in Cumberland, where about 5½ cwt. lime has been applied each alternate year in conjunction with artificials. At three of these centres, viz., Brampton on sandy loam, Gosforth on gravelly soil, and Wigton on poor clay, the gain per acre has been reduced by about 15s. in each case by the use of lime; and at one centre only, at Kirkbampton on loam, was there a slight increased gain of 1s. an acre. So far, therefore, the results do not encourage the use of lime for old land hay.

In all cases, the hay (calculated as dry hay) has been valued at 50s. a ton.

Suggestions for the manuring of old land hay.—The foregoing summary of the results of old land hay experiments, continued from nine to eleven years in the North of England, suggests the following:—

1. It is probable that nitrate of soda and, to a much larger extent, sulphate of ammonia are not profitable, but the reverse, as manures for old land hay.
2. An application of about 5 cwt. an acre of basic slag every three years, about 1 cwt. of fish meal every year, and about 2 cwt. of muriate of potash in most cases every three years, will probably be a good general plan of manuring per acre for old land hay. On the lighter class of soils, 10 tons of dung every three

years is likely to be a useful addition. On soils rich in lime superphosphate may be profitably substituted for basic slag, and on all soils other manures of a similar character to fish meal may take the place of this manure.

3. Special attention is directed to the excellent results given by the complex dressings of artificial manures in Set II. of the Cumberland hay experiments, which may in many cases be followed with advantage.
4. It is most desirable that the turf of old land hay should be prevented from becoming matty by the treading of grazing stock in the autumn and winter, and by judicious harrowing of the turf.

CUMBERLAND OLD LAND HAY EXPERIMENTS.

(SET I.)

The complete results of these experiments for nine years, 1895-1903, are contained in the tables on pages 16 and 17. The cost of the manures, the average annual increase over the unmanured plot, and the average annual profit or loss are given for each plot.

CENTRES AND CHARACTER OF SOILS.

Centre.	Occupier.	Nature of soil.
Blencow	Mr. M. Walker	Clay loam on Old Red Sandstone.
Low Flow, Glasson	Mr. Richardson	Peat.
Gelt Mill, Castle Carrock ...	Mr. J. W. Steele	Alluvial sand derived from New Red Sandstone.
Muncaster Head, Eskdale ...	Mr. T. Troughton	Medium loam on Granite.

TABLE I.—NINE YEARS OF CUMBERLAND OLD LAND HAY EXPERIMENTS. (SET I.)

PLOTS 1/10-ACRE. FIGURES PER ACRE.

Plot.	Manures for 1895-1903 (slightly different 1895).						Average annual cost of manures.		Yield of hay.												Plot.
									Blencow			Glasson			Gelt Mill, Castle Car'k.			Muncaster H'd, Eskdale			
	Dung.	Sulph. am.	Nitrate.	Super.	Slag.	Kainit.			1903.	Average of nine years	Average increase or decrease (-) over unmanured plot.	1903.	Average of seven years.	Average increase or decrease (−) over unmanured plot.	1903.	Average of nine years.	Aver. increase over unmanured plot.	1903.	Average of nine years.	Aver. increase over unmanured plot.	
	Tns	lb.	lb.	lb.	lb.	lb.	s.	d.	Cwt	Cwt	Cwt.	Cwt	Cwt	Cwt	Cwt	Cwt	Cwt	Cwt.	Cwt	Cwt	
1	..	..	..	..	..	..	..		23½	23	..	26½	16	..	16¾	20½	..	30	21¼	..	1
2	..	..	109	..	..	..	9	9	33¼	28½	5½	21½	15¾	− ¼	28	26	5½	31½	25¼	4	2
3	..	..	..	230	..	..	6	7	34	31¾	8¾	32	20½	4½	21	22¼	1¾	28¼	25¾	4½	3
4	..	..	..	..	200	..	4	6	35¾	19	−4	26¾	18	2	23	22¼	1¾	32	23	1¾	4
5	..	..	..	..	..	290	5	11	27¼	29¼	6¼	25	19½	3½	24¾	25¼	4¾	26¾	23¼	2	5
6	..	..	109	230	..	..	16	4	36½	32½	9½	27¼	24	8	25½	24¾	4¼	31¼	28½	7¼	6
7	..	..	109	..	..	290	15	8	37¼	30¾	7¾	28	20¾	4¾	30¾	29½	9	43½	32¼	11¼	7
8	..	..	..	230	..	290	12	6	42¾	28¾	5¾	27¾	22½	6½	37¼	30	9½	42¼	34½	13¼	8
9	..	..	109	230	..	290	22	3	44	31¼	8¼	28¼	24¾	8¾	37¾	32¾	12¼	44¼	36¾	15¼	9
10	..	..	109	..	200	290	20	2	41¾	31	8	38	27	11	41¼	32¼	11¾	36¼	35¼	14¼	10
11	..	..	109	115	100	290	21	2	33½	28¾	5¾	28¼	27	11	43¾	34½	14	36½	35	13¾	11
12	..	84	..	..	200	290	20	2	34½	27	4¾	30¾	26	10	39¾	31	10½	34¾	30	8¾	12
13	10*	42*	..	..	100*	145*	28	1	43	27¾	4¾	34½	24¾	8¾	46¼	36	15½	37½	30½	9¼	13
14	..	42	..	..	100	145	10	7	27½	26	3	35¼	22¼	6¼	35½	29¼	8¾	31¼	29¼	8	14
15	10†	42†	..	..	100†	145†	33	8	36½	30¾	7¾	39½	24	8	48¾	37¼	16¾	36¾	37¾	16½	15
16	10‡	..	..	..	..	..	27	9	39¼	29½	6½	36½	26½	10½	41¼	31¼	10¾	32¼	36	14¾	16

* Plot 13 got dung only in 1896, artificials only in 1897, and so on in alternate years.

† Plot 15 got dung and artificials in 1895, and in alternate years only thereafter.

‡ Plot 16 got dung in 1895, and in alternate years only thereafter (applied at Glasson in 1900 by mistake). Plot 14 got 84 lb. sulph. am. in 1900.

The hay at Glasson was not weighed in 1897 nor 1900. All the plots at Glasson got a light dressing of dung in the autumn of 1901.

Plots 9-12 receive standard dressing of 17·5 lb. nitrogen, 35 lb. phos. acid, and 35 lb. potash per acre.

PROFIT TABLE (II.)—CUMBERLAND OLD LAND HAY EXPERIMENTS.
(SET I.)

RESULTS PER ACRE. AVERAGE OF NINE YEARS.

Plot.	Manuring (annually).	Average annual cost of manures.		Average annual profit or loss (-).							
				Blencow (clay loam).		Glasson (peat).		Castle Carrock (alluvial soil on Permian sandstone).		Eskdale (loam on granite).	
		s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
1	No manure	...		...		...		...		...	
2	1 cwt. nitrate	9	9	4	0	-10	4	4	0	0	3
3	2⅝ cwt. super.	6	7	15	3	4	8	- 2	3	4	8
4	1⅞ cwt. slag	4	6	-14	6	0	6	- 0	2	- 0	2
5	2⅝ cwt. kainit	5	11	9	8	2	10	5	11	- 0	11
6	Nitrate and super. ...	16	4	7	5	3	8	- 5	9	1	9
7	Nitrate and kainit ...	15	8	3	8	- 3	10	6	10	12	5
8	Super. and kainit	12	6	1	10	3	9	11	3	20	7
9	Nitrate, super. and kainit	22	3	- 1	8	- 0	5	8	4	16	6
10	Nitrate, slag and kainit ...	20	2	- 0	2	7	4	9	2	15	11
11	Nitrate, ½ super., ½ slag and kainit	21	2	- 6	10	6	4	13	10	13	2
12	¾ cwt. sulph. am., slag and kainit	20	2	- 8	4	4	10	6	1	1	8
13	½ of artificials of Plot 12 each alternate year, and 10 tons dung in intervening years (artificials 1903)	28	1	-16	3	- 6	3	10	8	- 5	0
14	½ of artificials of Plot 12 ...	10	7	- 3	1	5	0	11	3	9	5
15	Same manures as Plot 13, but all in alternate years (no manures 1902, etc.)	33	8	-14	4	-13	8	8	2	7	7
16	10 tons dung each alternate year (dung 1903)	27	9	-11	6	- 1	6	- 0	11	9	1

Objects of experiments.—The chief object is to determine the relative value of nitrogen, phosphates and potash for producing hay on these soils. In addition, slag and superphosphate are compared as phosphatic manures, and nitrate and sulphate of ammonia as nitrogenous manures. A test is also made of the comparative value of dung and artificials.

NOTES ON RESULTS.

Glasson.—On this peat soil nitrate of soda only has given very bad results; phosphates only have given comparatively small returns, superphosphate, however, being more useful than slag; and kainit alone has little effect. When nitrate of soda is added to either superphosphate or kainit the profit is diminished. On plot 8 superphosphate and kainit give an annual profit of 3s. 9d. an acre, but when nitrate of soda is added to these manures this is converted into a loss of 5s. an acre.

It is very striking that at this centre when basic slag and superphosphate alone are tested against each other the latter gives the best result, whereas when these manures have nitrate of soda and kainit applied along with them then basic slag gives by far the best result. It would, therefore, be well worth while to try the effects of basic slag and kainit only on this land. These results, based as they are on a nine years' experiment, and given on plots alongside of each other, and to all appearance fairly comparable, suggest that here superphosphate can best make use of the soil potash, but that when potash is included in the manuring basic slag is more effective. It is generally recognised that basic slag is best for a peat soil, but these results throw doubt on this in certain cases, at any rate when the slag is not accompanied by a potash manure. The explanation is probably that this peat soil is rich in lime.

A comparison of plots 10 and 12 shows that sulphate of ammonia is not as useful as nitrate of soda, and the fact that a half dressing of artificials which includes sulphate of ammonia gives a slightly better result than the whole dressing may be due to the smaller dressing of sulphate of ammonia having done less harm.

As might be expected on this peat soil, dung is not effective but has given an annual loss wherever applied.

When the plots were inspected in July last it was found that kainit had developed sweet and clovery bottom herbage, which was of a still better character when a phosphatic manure was added. Dung has not much improved the herbage from its original condition, and where nitrate of soda and especially sulphate of ammonia have been added to phosphatic or potash manures, the effects of these latter in producing a finer herbage have been considerably retarded.

Mr. J. C. Grainger has given great assistance in the supervision of the plots.

Composition of the soil.—Mr. Collins has found that this soil is very rich in available phosphates and potash and that it contains as much as 2¼ per cent. of lime or the equivalent of about 4 per cent. of carbonate of lime. While it contains about 60 per cent. of organic matter, the earthy matter distributed throughout the peaty fibre is of a valuable character. Mr. Collins states that it is "a remarkably fertile soil from a chemical point of view."

As there is a great deal of similar soil in this district, these results should be of considerable local interest.

Castle Carrock.—The soil here is of a fine sandy character and is dark in colour because of organic matter. It lies on a River Terrace of the Gelt, which is surrounded by hills of the Glacial Sands and Gravels which overlie and are derived from red Triassic rocks. At this centre nitrate of soda alone has given a fair annual profit and kainit alone has done remarkably well, but neither superphosphate alone nor basic slag alone have been profitable. Superphosphate and kainit have given remarkably good results, but nitrate of soda added to these manures has diminished the annual profit by 3s. per acre. When basic slag took the place of superphosphate in a complete manure the results have been slightly better, and a most satisfactory result was obtained where the phosphate was applied half as slag and half as superphosphate, this being the best plot at this centre. Where sulphate of ammonia replaced nitrate of soda in a complete manure the annual profit was reduced by 3s. per acre, and the question is again raised as to whether continued dressings of sulphate of ammonia do harm, half the dressing of artificials on plot 14 (which include sulphate of ammonia) being much more profitable than a full dressing. At this centre, dung in judicious combination with artificials has given most satisfactory results on this sandy land, even though already rich in organic matter, but dung without the aid of artificials has not been profitable.

The herbage of the plots was examined in July last. The unmanured plot consisted mainly of fine grasses such as sheep's and hard fescue, dogstail and vernal, with a few clover plants. Neither nitrate nor superphosphate improved the character of the herbage, but basic slag had slightly developed clover plants. Kainit alone, on plot 5, has developed clovers, especially red clover, to a remarkable extent; and the same result was given on plot 8, where superphosphate and kainit were applied. There is no doubt that the hay grown on plot 8 is of much greater nutritive value than that of most of the other plots. On plot 9, where nitrate of soda was added to these manures, clovers were not so abundant.

The most striking result at this centre is the great effect of kainit—a potash manure.

Muncaster Head.—The soil here is only a few inches deep and is a dark moorish soil consisting of sand and organic matter lying on Granite rouble. It is in a poor high-lying mountainous district at the top of Eskdale and one mile from the town. It lies considerably above sea-level. On this soil neither nitrate of soda alone nor kainit alone have been effective. Superphosphate alone, however, has given a good result, although basic slag has not done so. The most profitable result has been given by superphosphate and kainit, the average annual profit from these manures being nearly 21s. per acre on this high-lying soil. Nitrate added to these has reduced the profit by 4s. per acre; and the same manure, added to superphosphate only, reduced the profit by 3s. per acre. In complete manures basic slag and superphosphate have been about equally effective. When sulphate of ammonia was used in a complete manure instead of nitrate a profit of 16s. per acre has almost entirely disappeared; but the better result by a half dressing of complete artificials which include sulphate of ammonia is suggestive. Dung on two of the plots has given profitable increases, but on one plot has not done so.

The herbage at this centre is a close bottom of good sheep pasture with no strong grasses, but a good deal of ribgrass and eyebright. Nitrate of soda has given a coarse dark-coloured herbage, while superphosphate and especially basic slag have given a sweeter bottom herbage with some clover. Kainit alone has decreased the amount of the herbage but has developed clover. By far the best herbage has been developed by kainit and superphosphate, this being close and nutritive, with abundance of clover. If the quality of the herbage on this plot were taken into account the profit shown on the table would be even greater than it is. On the dung plots the herbage is of a much coarser character and cannot be so nutritive.

Blencow.—The plots at this centre are in a field adjoining Blencow station. The soil is a clay loam resting on a red Boulder Clay which contains sandstone and limestone boulders. Underneath this are beds of limestone and sandstone of the Mountain Limestone. It is a healthy stock district, and there is much good arable and pasture land of a useful and true character.

Unfortunately the soil at this centre is very variable; that of plot 1 is deep and is a good red loam, whereas that of plot 11, and in a less degree plot 12, is much poorer and freer in character, and its dryness indicates that it is near rock. The results at this centre are given on the tables; they indicate that sulphate of ammonia is not as useful as nitrate of soda and that a dressing containing phosphates and potash is in the long run more profitable than a similar dressing to which nitrate of soda is added. Here also, when either basic slag or superphosphate is applied alone, the latter gives the best result, but when the same manures are part of mixed dressings slag is the better in its effects.

CUMBERLAND OLD LAND HAY EXPERIMENTS.
(SET II.)

The results of this set are contained in the tables on pages 24 and 25. Full details are given on this table of the plan of manuring, of the results of the nine years (1895-1903), and of the profit or otherwise from the various combinations of manures.

Objects of experiments.—These are (1) to ascertain in what proportion the three ingredients of a complete manure should be mixed; (2) to compare the effects of the phosphatic manures, superphosphate, basic slag, dissolved bones and bone meal; (3) to compare fish meal with other dressings; (4) to ascertain the effects of supplying nitrogen and phosphates from several sources in one dressing instead of in one manure only, respectively; (5) to test the effect of adding lime to artificial manures.

CENTRES AND CHARACTER OF SOILS.

Centre.	Occupier.	Nature of soil.
Cambeck Hill Farm, Brampton	Mr. J. P. Johnson ...	Sandy loam on Glacial and Alluvial Sands and Gravels overlying Red Triassic Sandstones.
Park Nook, Gosforth ...	Dr. Parker	Red sandy loam on gravel subsoil.
Fold House, Kirkbampton	Mr. J. Holliday ...	Loam on Boulder Clay overlying Red Sandstone.
Percy Hill, Wigton ...	Mr. H. W. Pallister	Poor stiff clay on Boulder Clay.

NOTES ON RESULTS.

It is important to note that the manures are practically applied in alternate years only in this set of experiments.

Castlesteads (Cambeck Hill Farm).—The soil on most of the plots is a red sandy loam containing a good deal of fibre, lying on an Alluvial Terrace. Plots 1, 8, 9, and 16 are on higher ground and lie on the Glacial Sands and Gravels. The soil of these plots is darker and freer, and has less fibre. This part of the field has been laid down comparatively recently but all the other plots are on very old turf.

The best result at this centre has been given by the half dressing of complex manures applied to plot 15, on which plot, at a cost of 7s. only per acre annually, a profit of nearly £1 per acre annually has been given. The full complex dressing on plot 14 has not been so profitable. On plot 10, the heavier dressing of slag, together with kainit and ½ cwt. nitrate, has given the excellent profit of 16s. 3d. annually. A comparison of plots 2 and 7 shows that the reduction of the nitrate by one-half has converted an annual loss to a handsome annual profit. The result on plot 16 indicates that lime is not profitable on this land. For the reasons stated above it is not desirable to compare plots 8, 9, and 16 with the other plots.

TABLE III.—NINE YEARS OF CUMBERLAND HAY (OLD LAND) EXPERIMENTS, 1895-1903. (SET II.)

PLOTS $\frac{1}{10}$-ACRE. FIGURES PER ACRE.*

Plot.	Manures for 1895, 1897, 1898, 1900, 1902 and 1903.								Average annual cost of manures.		Yield of hay.												Plot.
											Castle-steads, Brampton.			Park Nook, Gosforth.			Fold House, Kirkbamp'n.			Percy Hill, Wigton.			
	Nitrate.	Super.	Slag.	Diss. bones.	Bone meal.	Fish meal.	Kainit.	Lime.			1903.	Average of 9 years.	Aver. increase over unmanured plot.	1903.	Average of 8 years.	Aver. increase over unmanured plot.	1903.	Average of 9 years.	Aver. increase over unmanured plot.	1903.	Average of 9 years.	Aver. increase over unmanured plots.	
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	s.	d.	Cwt	Cwt	Cwt	Cwt	Cwt	Cwt	Cwt	Cwt	Cwt	Cwt	Cwt	Cwt	
1	..	..	..	..	..	..	.	..	..		27¾	22	..	24¼	26½	..	34	28½	..	23½	27	..	1
2*	109	328	..	..	..	..	412	..	18	4	35½	28¾	6¾	39	37¼	10¾	50	40	11½	39¾	33½	6½	2*
3	109	164	..	..	..	..	412	..	15	3	35½	27¾	5¾	37½	32½	6	44	40¾	12¼	37¼	32¼	5¼	3
4	109	492	..	..	..	..	412	..	21	5	3[illegible]	29¼	7¼	43	38	11½	41¾	37	8½	38½	36½	9½	4
5	109	328	..	..	..	..	206	..	15	6	33	27¾	5¾	35¾	33¾	7¼	37¼	34	5½	43	36½	9½	5
6	109	328	..	..	..	..	618	..	21	1	37½	30¾	8¾	38¾	34¾	8¼	36¼	37¼	8¾	36¼	36¾	9¾	6
7	54½	328	..	..	..	..	412	..	15	1	37½	32½	10½	37½	34¼	7¾	34	35	6½	33¾	32¼	5¼	7
8	163½	328	..	..	..	..	412	..	21	7	35¼	31¾	9¾	40¾	37¼	10¾	44½	39	10½	39	36¾	9¾	8
9	54½	..	284	..	..	..	412	..	13	0	30	30¼	8¼	33¾	33	6½	41¼	36½	8	46	38¼	11¼	9
10	54½	..	426	..	..	..	412	..	13	9	38¾	34	12	34	33	6½	41	36¼	7¾	39	37¼	10¼	10
11	..	..	..	326	..	..	412	..	15	3	36¼	30½	8½	34¾	35½	9	35½	34¼	6	36½	35¼	8¼	11
12	..	..	..	..	223	..	412	..	12	6	34	29	7	34	35½	9	40¾	36¼	7¾	37½	36½	9½	12
13	..	..	248	..	..	107	412	..	13	8	33¼	30¾	8¾	33¾	34	7½	34½	34½	6	29½	33¼	6¼	13
14†	22	66	107	65	45	21	412	..	14	0	34¼	33¾	11¾	37¾	37¾	11¼	38½	39¾	11¼	37½	34	7	14†
15	11	33	53½	32½	22½	10½	206	..	7	0	39¼	32¾	10¾	30½	29¼	2¾	27	32	3½	36	33	6	15
16	11	33	53½	32½	22½	10½	206	700‡	11	8	32½	27	5	26½	27	½	39¾	34¼	5¾	30¾	28¾	1¾	16

* This dressing supplies 17½ lb. nitrogen, 50 lb. phosphoric acid and 50 lb. potash.

† ,, ,, ,, 1-5th of the collective dressings of plots 7, 9,11, 12 and 13.

‡ This contains 500 lb. pure lime (CaO).

PROFIT TABLE (IV.).—CUMBERLAND OLD LAND HAY EXPERIMENTS. (SET II.)

FIGURES PER ACRE. AVERAGE OF NINE YEARS.

Plot.	Manuring (1895, 1897, 1898, 1900, 1902 and 1903).	Average annual cost of manures.		Average annual profit or loss (–).							
				Castlesteads, Brampton (sandy loam).		Park Nook, Gosforth (gravelly).		Fold House, Kirkbampton (loam).		Percy Hill, Wigton (poor stiff clay.)	
		s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
1	No manure	...		...		...		...		.	
2	1 cwt. nitrate, 3¾ cwt. super., 3¾ kainit *	18	4	– 1	6	8	6	10	5	– 2	1
3	As for plot 2, less half of super.	15	3	– 0	11	– 0	3	15	4	– 2	2
4	As for plot 2, but half more super.	21	5	– 3	4	7	4	– 0	10	2	4
5	As for plot 2, less half of kainit	15	6	– 1	2	2	8	– 1	9	8	3
6	As for plot 2, but half more kainit	21	1	0	9	– 0	6	0	9	3	3
7	As for plot 2, less half of nitrate	15	1	11	2	4	4	1	2	– 2	0
8	As for plot 2, but half more nitrate	21	7	2	9	5	3	4	8	2	9
9	As for plot 7, but slag (2⅝ cwt.) instead of super.	13	0	7	7	3	3	7	0	15	1
10	As for plot 9, but half more slag	13	9	16	3	2	6	5	8	11	10
11	2⅝ cwt. dis. bones, 3¾ cwt. kainit	15	3	6	0	7	3	– 0	3	5	4
12	1⅞ cwt. bone meal, 3¾ cwt. kainit	12	6	5	0	10	0	6	11	11	3
13	2⅝ cwt. slag, 1 cwt. fish meal, 3¾ cwt. kainit	13	8	8	2	5	1	1	4	1	11
14	One-fifth of collective dressings† of plots 7, 9, 11, 12 and 13	14	0	15	4	14	1	14	1	3	6
15	One-half of dressing for plot 14	7	0	19	10	– 0	2	1	9	8	0
16	As for plot 15, and 650 lb. lime (500 lb. pure lime)	11	8	0	10	– 10	5	2	8	– 7	4

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* This dressing contains 17½ lb. nitrogen, 50 lb. phosphoric acid, and 50 lb. potash

† This dressing contains 22 lb. nitrate, 84 lb. super., 112 lb. slag, 59 lb. dis. bones, 42 lb. bone meal, 22 lb. fish meal.

Park Nook.—The soil is a red sandy loam lying on a gravel subsoil, the gravel being derived from Silurian rocks, granite, and red sandstone.

The portions of plots 5 to 8 furthest from the drive have a poor thin soil, so that the other halves of the plots only have been weighed since 1903.

At this centre the complex dressing of plot 14 is most profitable, having given an annual profit of 14s. per acre; but when this dressing has been reduced by one-half the profit disappears, and when to this half dressing about 6 cwt. per acre of lime is added there is an annual loss of over 10s. per acre. At this centre superphosphate has proved to be more profitable in a mixed manure than basic slag (compare plot 2 with plots 9 and 10). On plot 12 bone meal and kainit has given an annual profit of 10s. per acre.

The herbage of the unmanured plot is poor and contains a great deal of rib-grass, ox-eye daisies and yellow-rattle. On plot 2 the mixed manure has considerably reduced these weeds, developed cocksfoot and given good mixed herbage, but where superphosphate has been increased or diminished the herbage is of poorer quality. Reduction of the kainit has also deteriorated the herbage but an increase of this has given more herbage with a closer and greener bottom. On the other hand, reduction of the nitrate has improved the herbage, whereas an increase of this has done the reverse. Basic slag has diminished the bulk but improved the quality of the herbage. Both dissolved bones and bone meal in combination with other manures have given sweet nutritious herbage, but lime added to the half dressing of complex manures has not improved the quality of the herbage but the reverse.

Fold House.—The soil at this centre is a dark deep sandy loam, lying on reddish drift several feet deep which is derived from red sandstone rock. There is a great deal of soil of somewhat the same character between Carlisle and Kirkbampton. Toward the latter the soil becomes darker in colour owing to accumulation of organic matter.

At this centre the standard dressing on plot 2 gives a good result, but on plot 3 the reduction of the superphosphate by one-half increases the annual profit by one-third, to over 15s. per acre; whereas on plot 4 where the superphosphate is increased, the profit has entirely disappeared. Increase or decrease of either kainit or nitrate of soda in all cases considerably reduces the profit. Plots 9 and 10 show that basic slag is not as profitable at this centre as superphosphate. The complex dressing on plot 14 gives an excellent result, but the reduction of this by one-half makes the profit almost disappear. A small dressing of lime annually is at this centre just profitable.

The herbage on the unmanured plot contains a good deal of plantain, Yorkshire fog, and poor grasses. On plot 2 yellow out grass, meadow vetchling and suckling clover have been developed and the herbage is of nice quality. Where the potash manure is reduced, leguminous plants are scarce, but where the same manure is increased these plants are well developed. Increase of nitrate has increased plantain and decreased clovers. Slag has given excellent and nutritive herbage, although deficient in quantity; but lime has not improved the quality of the herbage.

Percy Hill.—The soil is a heavy clay which cracks in seasons of drought. The subsoil is Boulder Clay, which is very stiff, and comparatively free from stones, and overlies the Coal Measures. At this centre the standard dressing on plot 2 has given a poor result, and so also does less superphosphate, but more superphosphate is better. Evidently this clay does not require potash, as on plot 5 where the potash is decreased the profit is quite a satisfactory one. On plot 9 where basic slag takes the place of superphosphate there is an annual profit of 15s. per acre—a most satisfactory result. When the slag is increased, however, the profit is not so satisfactory. Bone meal in conjunction with kainit has given an excellent result, but the complex dressing has not been satisfactory at this centre. A small annual application of lime in conjunction with artificial manures has given most disappointing results, as it has converted an annual profit of 8s. per acre into a loss of nearly the same amount.

The herbage of the unmanured plot has a great deal of plantain and buttercups, with a fair amount of dogstail, vernal, cocksfoot, brome and other grasses, and a few red clover plants. On plot 2 the weeds have been reduced and white clover developed, and the herbage was of good quality. The reduction of superphosphate has given poorer herbage. Increased kainit has not improved the herbage, thus indicating that a potash manure is not wanted. Increased nitrate has given less clover but more grassy herbage; and basic slag has developed clovers, especially red clover, to the greatest extent, while dissolved bones and bone meal have also given nice quality herbage.

BROOMHAUGH OLD LAND HAY EXPERIMENT.

Table V., page 29, contains a summary of the results for eleven years of an experiment on the manuring of old land hay on Mr. C. Marshall's farm, Broomhaugh, Riding-Mill-on-Tyne.

The soil.—This is poor, light, and sandy; and lies on Millstone Grit sandstone.

TABLE V.—ELEVEN YEARS OF EXPERIMENT ON OLD LAND HAY AT BROOMHAUGH, NORTHUMBERLAND, 1893-1903. (B PLOTS.)

PLOTS 1/10-ACRE. FIGURES PER ACRE.

Plot.	Manures applied annually.	Average annual cost of manures.		Amount of hay.				Average annual profit or loss (–).		Plot.
				1903.	Eleven years, 1893-1903.	Average of eleven years.	Average increase over unmanured plot.			
		s.	d.	Cwt.	Cwt.	Cwt.	Cwt.	s.	d.	
1	No manure	...		9½	108¾	10	...	...		1
2	1 cwt. nitrate of soda ...	9	9	11¾	149¾	13½	3½	–1	0	2
3	3¾ cwt. basic slag ...	8	11	14	149	13½	3½	–0	2	3
4	2⅝ cwt. kainit	5	11	7	109	10	...	–5	11	4
5	1 cwt. nitrate and 3¾ cwt. slag	18	8	14¾	186½	17	7	–1	2	5
6	1 cwt. nitrate and 2⅝ cwt. kainit	15	8	10¾	147¾	13½	3½	–6	11	6
7	3¾ cwt. slag and 2⅝ cwt. kainit	14	10	24	237	21½	11½	13	11	7
8	1 cwt. nitrate and 3¾ cwt. slag and 2⅝ cwt. kainit	24	7	26	277¼	25¼	15¼	13	6	8
9	¾ cwt. sulph. am., 3¾ cwt. slag and 2⅝ cwt. kainit	24	7	17	203¼	18½	8½	–3	4	9
10	1 cwt. nitrate, 2⅝ cwt. super., and 2⅝ cwt. kainit	22	3	17¼	214¾	19½	9½	1	6	10
11	10 tons dung in alternate year*	27	3	22¾	282¾	25¾	15¾	12	2	11

* Plot 11 got dung in 1893, 1894 and alternate years thereafter; except 1902.

NOTES.—The standard dressing, in lb. per acre, consists of:—nitrogen, 17·5 lb., phosphoric acid, 70 lb. (except plot 10 which receives 35 lb. only), and potash, 35 lb.

In 1893 and 1894 the artificial dressings were:—1 cwt. nitrate, ¾ cwt. sulph. am., 4½ cwt. slag, 3 cwt. super., and 5 cwt. kainit.

No manure was applied in 1895.

NOTES ON RESULTS.

Effects of nitrate of soda and sulphate of ammonia:

Plot.	Manuring (annually).	Average yield in 11 years. 1893-1903.	Average annual profit.
		Cwt.	s. d.
1	No manure	10	...
2	1 cwt. nitrate	13½	–1 0
8	1 cwt. nitrate, 3¾ cwt. basic slag, 2⅝ cwt. kainit	25¼	13 6
9	¾ cwt. sulph. am., 3¾ cwt. basic slag, 2⅝ cwt. kainit	18½	–3 4
7	3¾ cwt. basic slag, and 2⅝ cwt. kainit ...	21½	13 11

For some reason or other sulphate of ammonia continues to give a remarkably poor result (plot 9) on this light sandy soil, yet gives excellent results when applied in combination with other manures (plot 8), does far better than sulphate of ammonia, but the omission of nitrate on plot 7 slightly increases the profit from the use of basic slag and kainit. There is no doubt also that the feeding value of the hay of plot 7 is very considerably greater (see results of Palace Leas hay experiment at Cockle Park) than that of either plots 8 or 9, and the hay from plot 7 is apparently much the best in quality.

Action of basic slag on light land.—This experiment shows that on a light sandy soil which is poor in lime, basic slag, although not acting by itself as it usually does on a clay soil, which is poor in lime, gives an excellent result in combination with a potash manure.

Plot.	Manuring (annually).	Average yield in 11 years. 189 -1903.	Average annual profit or loss (–).
		Cwt.	s. d.
1	No manure	10	...
3	3¾ cwt. basic slag	13½	0 2
7	3¾ cwt. basic slag, and 2⅝ cwt. kainit ...	21½	13 11
4	2⅝ cwt. kainit	10	–5 11

On plot 3 basic slag gives an appreciable, but not a profitable, increase of the crop, and on plot 4 kainit gives no more crop than is produced without any manures, but on plot 7 slag and kainit combined give an annual profit of 13s. 11d. an acre, and this profit would be considerably greater if the better feeding value of the hay were taken into account! On plot 5 nitrate of soda added to slag gives a loss and not a profit, and this is also so on plot 6 where nitrate is added to kainit.

Basic slag and superphosphate as phosphatic manures on this land.—On plot 8 a complete manure, with basic slag as the phosphatic manure, gives an annual profit of 13s. 6d. an acre, whereas on plot 10, where superphosphate takes the place of basic slag in the complete manure, the profit is reduced to 1s. 6d. an acre. Basic slag, therefore, is evidently much better suited than superphosphate for old land hay on this sandy soil. Its poorness of lime probably favours the action of basic slag but not of superphosphate. It should be here stated that the amount of phosphates applied in the basic slag is double of that in the superphosphate; but in each case the quantity applied is about the right quantity to give the best results. Half the amount of basic slag would probably have been insufficient while double the amount of superphosphate might have been injurious.

Farmyard manure.—This, applied at the rate of 10 tons an acre each alternate year, on plot 11, has given very satisfactory results on this light sandy soil, and an annual profit of 12s. 2d. an acre.

Dr. Potts made the following notes on the appearance of plots before the hay was cut in July, 1903:—

Plot 1: A sole of moss, with scanty and stunted herbage; some birdsfoot trefoil.

Plot 2: Very little bottom grass; heads of stunted hard fescue abundant, also Yorkshire fog and yarrow.

Plot 3: A thick sole of moss with a large proportion of plantain, and a few strong clover plants.

Plot 4: A very poor plot, almost devoid of vegetation except for a little plantain.

Plot 5: A very mossy plot, with only a few weakly clover plants.

Plot 6: A very poor plot. Herbage with a very black appearance, and consisting almost entirely of wood rush and hard fescue.

Plot 7: An excellent plot with a very healthy appearance, and presenting a capital sheep bite, which consists of a thick sole of clover intimately mixed with the finer grasses; no moss.

Plot 8: This plot is more forward than any other of the series. A thick sole of short sweet grass intimately mixed with clover.

Plot 9: A very poor plot; a striking contrast to plot 8. Grass scarce and wiry, and clover very weakly.

Plot 10: A very good plot, though the clovers are not nearly so strong, nor the grasses so vigorous as on plot 8.

Plot 11: Herbage with a very healthy colour and consisting of mixed grasses and clovers.

Composition of the soil.—Mr. Collins has analysed the soil of the unmanured plot and has found it to be of a very poor character. It contains 14 per cent. of stones, and nearly 6 per cent. of organic matter. It is remarkably poor in available potash and especially in available phosphates, and contains only ¼ per cent. of lime. The small amount of lime present has probably a good deal to do with the greater effectiveness of basic slag than of superphosphate on this soil.

SEAHAM OLD LAND HAY EXPERIMENT.

This experiment on the manuring of old land hay is being made on the Seaham Harbour Stud Company's land at Carr House farm, Seaham Harbour. Particulars are contained in Table VI., page 34.

The soil.—This is a medium loam, and lies on a subsoil of Boulder Clay which overlies the Magnesian Limestone.

The results.—These are not satisfactory, the main reason being probably the variable character of the soil and subsoil.

On seven of the twenty plots over 2 cwt. an acre of superphosphate has been applied annually, and in all cases this amount of superphosphate has given an annual loss, this being greatest on plot 3, where over 5½ cwt. of superphosphate have been applied annually. Although this soil overlies Magnesian Limestone rock, it is probably poor in lime, and for this reason unsuitable for superphosphate. On plot 4 also a heavy dressing of kainit annually gives a considerable annual loss. Again, if plots 17 and 18 are compared it is found that where superphosphate and kainit are reduced by half (in common with the other manures) that the profit is greatly increased. Evidently this land is easily overdosed with these manures. There are no doubt considerable areas of land where this is so, and those who are farming land of somewhat the same character may save themselves considerable expense by noting these results. Dung only (plot 20), and especially a half dressing annually of a complex manurial dressing (plot 18), have given the most satisfactory results.

TABLE VI.—TEN YEARS OF EXPERIMENT ON OLD LAND HAY AT SEAHAM, CO. DURHAM, 1894-1903.

PLOTS $\frac{1}{20}$-ACRE. FIGURES PER ACRE.

Plot.	Manuring 1891-1903, nothing in 1895.									Average annual cost of manures.		Amount of crop.			Plot.
	Dung.	Sulph. am.	Nitrate of soda.	Super.	Slag.	Dis. bones.	Fish meal.	Kainit.	Lime shells.			1903.	Average of 10 years.	Average increase over unmanured plot.	
	Tons.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	s.	d.	Cwt.	Cwt.	Cwt.	
1	...	...	...	...	...	...	...	...	...	...		36	25¾	...	1
2	...	...	112	...	...	...	...	...	...	8	9	39½	30¼	4½	2
3	...	...	...	840	...	...	...	...	...	16	10	36½	25¾	...	3
4	...	...	...	...	...	...	...	588	...	10	8	30	23¼	2½	4
5	...	...	56	420	...	...	...	...	...	12	10	36	29½	3¾	5
6	...	...	56	...	294	...	...	...	...	10	0	41	28½	2¾	6
7	...	...	56	...	...	...	...	294	...	9	8	40	27¾	2	7
8	...	...	56	420	...	...	...	...	325	16	0	42¼	28½	2¾	8
9	...	...	56	420	...	...	...	294	...	18	2	43	29	3¼	9
10	...	...	56	...	294	...	...	294	...	15	4	42½	32	6¼	10
11	...	...	...	420	...	...	...	294	...	13	10	35½	27¾	2	11
12	...	...	37	280	...	...	...	193	...	12	1	41½	31½	5¾	12
13	...	...	56	210	147	...	...	294	...	16	9	49½	36	10¼	13
14	...	...	...	...	...	294	...	294	...	18	4	44½	32¾	7	14
15	...	...	...	366	...	...	112	294	...	18	5	46	31¾	6	15
16	...	42	...	420	...	...	...	294	...	18	2	47	30½	4¾	16
17	...	8½	22	241	59	57	22	294	...	17	8	54	34¼	8½	17
18	...	4¼	11	120	29½	28½	11	147	...	8	10	60	36¼	10½	18
19	10*	4¼*	11*	120*	29½*	28½*	11*	147*	...	30	11	59	41¼	15½	19
20	10†	...	...	...	...	...	...	...	...	25	0	52	40¾	15	20

*Plot 19 got dung and artificials for 1894 and 1896, but nothing for 1895; in 1897 it got artificials, and 1398 dung, and so on in alternate years.

†Plot 20 got dung in 1894 and every alternate year thereafter.

NOTES.—The standard dressing per acre for plot 14 is 8·75 lb. nitrogen, 50 lb. phosphoric acid, and 35 lb. potash; this has been supplied since 1900. Before that year 38 lb. phosphoric acid were applied. Lime shells for plot 8 contained 250 lb. caustic lime. Plot 17 gets one-fifth, and plot 18 one-tenth of collective dressings of plots 9, 10, 14, 15, and 16.

The manuring of Swedes, Potatoes and Mangels.

By C. BRYNER JONES.

EXPERIMENTS ON THE MANURING OF SWEDES.

Experiments on the manuring of swedes and turnips were conducted, during season 1903, at twelve stations in the county of Durham and one station in Northumberland. The names of the centres and the character of the soil at each are given in Table VII., page 36.

Objects.—(1) To ascertain the special requirements of the crop in the way of manurial ingredients; (2) to compare the value of basic slag and superphosphate; (3) to compare the effects of dung and artificials; and (4) to determine the most satisfactory dressing of artificials to use in conjunction with dung.

Results.—The manures used and the produce obtained at eleven centres are given in Table VIII., page 37. At two centres the crop was not weighed. Last season was very unfavourable, and the crops as a rule were light. The average crop at eight centres is shown in Table IX., page 38. The Tow Law results are left out of the averages, as the crop was so light.

TABLE VII.—CENTRES FOR SWEDE EXPERIMENTS.

No.	Centre.	Owner or occupier.	Soil and geological formation.	Previous crop and manuring per acre.	Variety grown.
1	Middleton House, Gainford	Mr. T. S. Todd	Clay loam of good quality on Boulder Clay	Oats ; 3 cwt. dissolved bones	Conqueror
2	Denton Grange Heighington	Mr. T. W. Stephenson	Strong loam on Boulder Clay overlying Magnesian Limestone	Oats ; ½ cwt. sulphate of ammonia	Toogood's Favourite
3	High Farm, Ryhope	Mr. E. Greenshields	Very good light soil on the Glacial Sands and Gravels	Potatoes; 35 loads dung applied in autumn	Kangaroo
4	Earl's House, Durham	Durham County Council	Very strong loam on Boulder Clay	Oats; no manure	Best of All
5	Hartburn Grange, Stockton-on-Tees	Mr. W. Whitell	Poorish stiff clay on Boulder Clay	Oats ; no manure	Best of All
6	Brackwood Hill, Hamsterley	Mr. R. Coatsworth	Light soil on the Middle Coal Measures	—	Brydon's Perfection
7	Hollin Hill, Hamsterley	Mr. T. Hedley	Loam in good condition on the Middle Coal Measures	Oats ; ¾ cwt. nitrate of soda	Kangaroo
8	Diamond Hall, Sedgefield	Mr. G. B. Bell	Strong loam on Boulder Clay	Oats ; 1 cwt. nitrate of soda	XL All
9	South Field Farm, Lintz Green	Mr. W. Thompson	Strong loam on Boulder Clay	Oats ; a medium dressing of nitrate of soda	Finney's Barnwood
10	Marwood, Barnard Castle	Mr. A Amos	Light gravelly soil on the Glacial Sands and Gravels	Oats ; no manure	Hybrid
11	Tow Law	Mr. T. Hall	Medium soil on the Middle Coal Measures	—	Bronze Top
12	Tow Law	Mr. G. Tomlinson	—	—	—
13	Lawson's Farm, Whittonstall	Mr. A. Thompson	—	—	—

TABLE VIII.—EXPERIMENTS ON THE MANURING OF SWEDES.

PLOTS 1/37-ACRE. RESULTS PER ACRE.

The standard dressing consists of 1 cwt. nitrate, ¾ cwt. sulphate of ammonia, 4 cwt. superphosphate, 2½ cwt. slag, and ⅞ cwt. muriate of potash. This contains 35 lb. nitrogen, 100 lb. phosphoric acid, and 50 lb. potash.

Plot.	Manure per acre.	Middleton House.		Denton Grange.		Ryhope.		Earl's House.		Hartburn Grange.		Brackwood Hill		Hollin Hill.		Diamond Hall.		South Field.		Marwood.		Tow Law. (Mr. Hall)	
		T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.
1	No manure	10	15½	5	12½	7	17½	5	16¾	6	2½	4	0	8	0	10	18¼	9	18½	7	8½	3	2¼
2	Standard dressing	18	16¾	18	5	10	5¾	9	15	12	19¼	17	7½	14	10½	12	10	15	8¼	21	15	3	18½
3	Stan. dress., but with phosphoric acid all as slag (5¼ cwt.)	15	15	10	0½	11	14¾	9	8¼	10	0¼	16	0	14	17½	18	10	15	2¼	18	10	3	0
4	Stan. dress., but with phosphoric acid all as super. (8 cwt.)	18	5¼	12	7½	12	6¾	11	4¼	12	1½	17	5	10	9¼	14	10½	15	1	20	0	4	1½
5	Stan. dress. without nitrogen	14	15	9	5	9	0¾	8	7¼	5	7¼	14	0	8	7½	12	5¼	11	6½	12	15	2	17¼
6	Stan. dress. without phosphoric acid	12	0	...		12	10¾	10	7½	...		1	17½	9	15	9	17½	12	4	8	10½	5	1½
7	Stan. dress. without potash	12	16¾	8	7½	12	13	10	6¾	...		21	10	14	0½	12	8	13	10½	13	15	5	1½
8	12 tons dung	16	6¼	8	15	12	9¼	12	16¼	8	16	14	0	11	19	15	5¼	15	6¾	16	0	5	5
9	12 tons dung and stan. dress. ...	18	19¼	14	0	15	1	15	1¼	14	0	21	0	14	8½	16	11½	17	8½	21	0	7	8½
10	12 tons dung and stan. dress. without nitrogen	16	10	10	17½	10	10	12	4¾	10	8¼	19	0	12	0	17	5	13	7¾	17	10	5	11¼
11	12 tons dung and stan. dress without phosphoric acid	16	8¼	...		12	1½	14	18½	12	15¼	14	0	11	18½	16	10	13	17¾	17	0	6	6¼
12	12 tons dung and stan. dress. without potash	18	10¼	11	12½	13	7¾	13	17¾	15	5	20	6½	18	0	16	17½	16	18½	18	10	4	0
13	12 tons dung and 4 cwt. super.	16	15	11	15	9	17¾	12	7½	10	19¾	9	9¼	5	15	17	0	18	0	16	15	5	8½

TABLE IX.—SWEDE EXPERIMENTS, 1903.

AVERAGE CROP AT EIGHT CENTRES, WITH COST OF MANURE AND PROFIT OR LOSS PER ACRE.

Plot.	Manure per acre.	Cost of Manure.			Average crop at eight centres.		Increase over unmanured plot.		Profit or loss (−) Swedes at 8s. per ton.		
		£	s.	d.	T.	C.	T.	C.	£	s.	d.
1	No manure		...		8	0¾	...			...	
2	Standard dressing	2	3	8	15	0½	6	19¾	0	12	3
3	Stan. dress., but with phosphoric acid all as slag	2	0	2	14	7¼	6	6½	0	10	5
4	Stan. dress., but with phosphoric acid all as super.	2	7	2	14	17¾	6	17	0	7	7
5	Stan. dress, without nitrogen ...	1	4	2	11	7¼	3	6½	0	2	4
6	Stan. dress., without phosphoric acid	1	7	2	9	0¼	0	19½	−0	19	4
7	Stan. dress., without potash ...	1	16	0	13	17½	5	16¾	0	10	8
8	12 tons dung	3	0	0	14	4	6	3¼	−0	10	9
9	12 tons dung and stan. dress ...	5	3	8	17	8¾	9	8	−1	8	6
10	12 tons dung. and stan. dress. without nitrogen	4	4	2	14	8½	6	7¾	−1	13	1
11	12 tons dung and stan. dress. without phosphoric acid	4	7	2	14	11¼	6	10½	−1	15	0
12	12 tons dung and stan. dress. without potash	4	16	0	16	8½	8	7¾	−1	8	11
13	12 tons dung and 4 cwt. super. ...	3	10	0	12	12½	4	11¾	−1	13	4

The most important ingredient for swedes.—The following table, abstracted from the average results, shows the relative importance of a complete manure and of manures from which one ingredient is omitted:—

Plot.	Manure per acre.	Cost of manure.			Average crop at eight centres.		Increase over unmanured plot.		Profit or loss (−) per acre.		
		£	s.	d.	T.	C.	T.	C.	£	s.	d.
1	No manure		—		8	0¾	—			—	
2	Standard dressing	2	3	8	15	0½	6	19¾	0	12	3
5	Stan. dress. but **no nitrogen**	1	4	2	11	7¼	3	6½	0	2	4
6	Stan. dress. but **no phosphates**	1	7	2	9	0¼	0	19½	−0	19	4
7	Stan. dress. but **no potash**	1	16	0	13	17½	5	16¾	0	10	8

On the average, therefore, phosphates were of greatest importance, while nitrogen was second and potash third. At the same time, the complete manure applied to plot 2 has been most profitable. The relative importance, however, of these ingredients at the different stations varied considerably as is shown by the following:—

Middleton House:	phosphates,	**potash,**	nitrogen.
Ryhope:	nitrogen,	**phosphates,**	potash.
Earl's House:	nitrogen,	**potash,**	phosphates.
Brackwood Hill:	phosphates,	**nitrogen,**	potash.
Hollin Hill:	nitrogen,	**phosphates,**	potash.
Diamond Hall:	phosphates,	**nitrogen,**	potash.
South Field:	nitrogen,	**phosphates,**	potash.
Marwood:	phosphates,	**nitrogen,**	potash.

Superphosphate v. basic slag.—The relative effects of these two manures were as follow:—

Plot.	Manure per acre.	Cost of manure.			Average crop at eight centres.		Increase over unmanured plot.		Profit per acre.		
		£	s.	d.	T.	C.	T.	C.	£	s.	d.
1	No manure		—		8	0¾	—			—	
2	Stan. dress. (phosphoric acid partly as super., and partly as slag)	2	3	8	15	0½	6	19¾	0	12	3
3	Stan. dress., but with phosphoric acid all as slag	2	0	2	14	7¼	6	6½	0	10	5
4	Stan. dress., but with phosphoric acid all as super.	2	7	2	14	17¾	6	17	0	7	7

It will be seen, as far as the yield is concerned, that superphosphate produced on the average slightly over half a ton per acre more swedes than basic slag, but this increase was not sufficient to cover the extra cost of the former, so that basic slag has given the more profitable results. This confirms the results of previous seasons, although not quite to the same extent. A mixture of the two produced slightly better results than either did alone.

Dung v. artificials.—Dung is generally used for the root crop. This is a convenient crop for getting the dung mixed with the soil and as a rule it has a good effect on roots. Very satisfactory crops of swedes, however, may be produced by artificials alone, and, if we leave out of consideration the *other* crops in the rotation, at less cost also than with dung. The average results for last year show that this is so:—

Plot.	Manure per acre.	Cost of manure.			Average crop at eight centres.		Increase over unmanured plot.		Profit or loss (–) per acre.		
		£	s.	d.	T.	C.	T.	C.	£	s.	d.
1	No manure		—		8	0¾	—			—	
2	Stan. dress., **artificials** ...	2	3	8	15	0½	6	19¾	0	12	3
8	12 tons **dung**	3	0	0	14	4	6	3¼	–0	10	9

The effects of dung, however, may be the more profitable when the subsequent crops of the rotation are taken into account. At Ryhope, Earl's House, and Diamond Hall there was, however, a considerably better crop from dung than from the standard artificial dressing. On the whole it may be concluded that not only may satisfactory crops of swedes be produced with suitable artificials alone, as has already been pointed out in former reports, but also that it may often pay better, if we exclude the residual value, to use artificials in preference to dung. It is largely on account of its indirect effects and residual value, as well as on the place which swedes occupy in the rotation, that dung is applied with advantage to this crop.

Artificials with dung.—Previous experiments on swedes carried out by the College authorities have shown that it is seldom directly profitable to use artificials along with farmyard manure for this crop. Last year the results were as follow:—

Plot.	Manure per acre.	Cost of manure.			Average crop at eight centres.		Increase due to artificials.		Loss per acre.		
		£	s.	d.	T.	C.	T.	C.	£	s.	d.
8	12 tons dung	3	0	0	14	4	—		0	10	9
9	12 tons dung and stan. dress.	5	3	8	17	8¾	3	4¾	1	8	6
10	12 tons dung and stan. dress. **without nitrogen**	4	4	2	14	8½	0	4½	1	13	1
11	12 tons dung and stan dress. **without phos. acid**	4	7	2	14	11¼	0	7¼	1	15	0
12	12 tons dung and stan. dress. **without potash**	4	16	0	16	8½	2	4½	1	8	11
13	12 tons dung and 4 cwt. super.	3	10	0	12	12½	loss 1	11½	1	13	4

There was on the average a loss throughout, consequent upon the use of artificials along with dung. It is true that on plots 9 and 12 there had been a considerable increase in the crop, but the increase, if we take swedes at their feeding value, was totally out of proportion to the additional cost of the manure. The increase on plot 9, where the loss was least, was only about one half of what it should have been to cover the total cost of the dressing applied. At Hartburn Grange, and Brackwood Hill, artificials added to dung certainly did cause a substantial increase on some of the plots, but even here the combined dressing has but little to recommend it in comparison with artificials alone. These results confirm those of previous years.

Nitrogen and phosphoric acid seem to be on the whole the most necessary ingredients with dung. Potash, except in certain cases, need not be added. When used with dung, there is reason to believe that the efficiency of potash manures depends more on the composition of the dung than on the character of the soil. In any case, the "complete" dressing caused a greater increase even with dung than any of the other mixtures, but, as already shown, it was not profitable.

Superphosphate alone is commonly used with dung for swedes, but last year it did not pay for itself except at Denton, Hartburn Grange, and Diamond Hall. On the average, it caused a considerable reduction in the crop.

The profit and loss results.—In all cases the whole cost of the manures is charged to the swede crop, but at least half of this might be charged to the following crops.

CONCLUSIONS.

(1) On the average of eight centres, phosphoric acid proved last season to be the most important manurial ingredient for the swede crop, and potash the least.

(2) Seeing that soils and seasons vary so much in character, it is as a rule safer to use "complete" dressings, when artificials alone are applied.

(3) Superphosphate has given on the average a slightly better crop than basic slag, but the latter has been the more profitable, while a mixture of the two is still more so.

(4) Dung alone did not on the average prove so profitable as artificials alone, so far as the swede crop was concerned.

(5) The addition of artificials to dung resulted financially in a very considerable loss throughout.

(6) Potash was the least necessary ingredient when artificials were used in conjunction with dung, although "complete" artificials gave slightly the best return.

(7) Superphosphate with dung proved on the whole to be less profitable than dung alone and still less so than the standard artificials alone.

(8) While dung alone paid better than any combination of artificials with dung, the most profitable results were obtained from artificials alone as applied to plot 2.

EXPERIMENTS ON THE MANURING OF POTATOES.

Experiments on the manuring of potatoes were made at seven centres in the county of Durham and one in Northumberland. Particulars relating to the different centres are given in Table X., page 44.

Objects.—(1) To indicate the most necessary class of manure for potatoes under the conditions prevailing in the district; (2) to test the value of potash from different sources; (3) to compare the effects of dung and artificial manures; (4) to ascertain how far it is profitable to use artificials and dung together for potatoes.

Soil.—Particulars relating to the soil are given in Table X., from which it will be seen that it varied considerably. Some of the soils responded to manurial treatment better than others, and it was not altogether where the condition of the land was poorest that the most consistent results were obtained. The lighter soils gave on the whole the best crops.

Results.—The plan of manuring and the results at the eight centres are given in Table XI., page 45. The results were fair in spite of the unfavourable season. At Hoppyland Park the crop was a comparative failure, due partly to the late planting on this heavy land, owing to the wet season, and partly to the heavy soil adversely affecting the crop. The average yield was greatest at Broad Oak; while the results at Mordon House were also good, but very erratic, the unmanured plot there being better than many of the others. At West Shaws only one drill in each plot was weighed, and the large and small potatoes were taken together.

TABLE X.—CENTRES FOR POTATO EXPERIMENTS.

No.	Centre.	Owner or occupier.	Soil and geological formation.	Previous crop and manuring.	Variety grown.
1	Ingleton	Mr. T. Burton	Loam of fair quality, on Boulder Clay	Beans; no manure, dressing of gas-lime in autumn	Up-to-date
2	Raby Home Farm...	Rt. Hon. Lord Barnard	Sandy loam, rather stony, on Boulder Clay	Barley; no manure ...	British Queen
3	Harelow Farm, Wolsingham	Mr. T. Stobbs	Gravelly loam, deep and rich, on River Gravel Terraces	Tares; no manure ...	British Lion
4	Hoppyland Park, Witton-le-Wear	Mr. G. I. L. Blenkinsopp	Poor clay soil on Boulder Clay	Oats; no manure ...	—
5	Old Burdon, Sunderland	Mr. T. B. Tiplady ...	Clay loam of poorish quality with sandy subsoil lying on the Glacial Sands and Gravels	Turnips, with light dressing dung in autumn, and 4 cwt. super., 2 cwt. dissolved bones, and 2 cwt. vitriolised bones in drill	Up-to-date
6	West Shaws West, Barnard Castle	Mr. Henry Brown ...	Medium soil on Boulder Clay	Vetches, with 3 cwt. super.	Maincrop
7	Mordon House, Ferryhill	Mr. T. Gibson	Light loam of good quality derived from Boulder Clay, Glacial Sands, and peat	—	Langworthy
8	Broad Oak, Ebchester	Mr. R. Dixon	Sandy soil, dry and stony, on Glacial Sands and Gravels	Grass for three years; no manure	Up-to-date

TABLE XI.—EXPERIMENTS ON THE MANURING OF POTATOES, 1903.

PLOTS $\frac{1}{27}$-ACRE. RESULTS PER ACRE.

The standard dressing consists of 1⅛ cwt. nitrate, ⅞ cwt. sulphate of ammonia, 3 cwt. superphosphate, and 1 cwt. muriate of potash. This contains 40 lb. nitrogen, 40 lb. phosphoric acid, and 60 lb. potash.

Plot.	Manure per acre.	Ingleton.	Raby.	Harelow.	Hoppylard Park.	Old Burdon.	West Shaws.	Mordon House.	Broad Oak.
		T. C.	T. C.	T. C.	T. C.	T. C.	T. C.	T. C.	T. C.
1	No manure	0 10¾ (0 9½)	2 19¼ (1 14¼)	2 16½ (0 9¼)	0 11 (0 15¼)	2 2 (0 11¾)	3 3¾	7 13¾ (0 11)	5 5 (2 1½)
2	Standard dressing	3 8¼ (1 3¾)	6 18¾ (2 7½)	4 16 (0 6)	1 10½ (1 10½)	4 7½ (0 11¼)	4 17	11 0 (0 8¼)	7 18¼ (1 16)
3	Stan. dress., but with potash as kainit (4 cwt.)	3 8½ (1 3¾)	6 16¼ (2 7¾)	5 1 (0 5½)	0 14¼ (0 19¾)	3 12¾ (0 8)	6 6	8 12½ (0 7)	7 6¼ (1 17¾)
4	Stan. dress., but with potash as sulphate of potash (1 cwt.)	3 2¾ (0 16¼)	6 0¼ (2 13½)	6 13 (0 5¾)	1 11½ (1 15)	3 15½ (0 7)	5 7	8 13¼ (0 6¼)	7 2¾ (1 19¼)
5	Stan. dress. without nitrogen	2 8¾ (0 14½)	4 3¾ (2 6¼)	4 3 (0 4¼)	0 9½ (0 18½)	3 1¼ (0 7)	3 16¾	5 12¾ (0 12)	6 4¼ (1 17¾)
6	Stan. dress without phosphoric acid ...	2 18¼ (0 17¾)	5 17¼ (2 10½)	2 10 (0 3)	1 3¼ (1 2)	3 5 (0 5½)	4 11¼	7 15 (0 6¼)	6 1 (1 18½)
7	Stan. dress. without potash	1 3¾ (0 17)	3 0½ (2 17¼)	4 11 (0 8¼)	0 8½ (1 6)	3 0 (0 9½)	4 9¾	5 13½ (0 15)	7 16¼ (1 17½)
8	12 tons dung	4 10 (1 0¼)	9 0 (3 4¼)	6 19½ (0 4¾)	1 13¾ (2 1)	3 12¾ (0 13¼)	5 1¼	7 15½ (0 10½)	9 9 (1 16¾)
9	12 tons dung and stan. dress.	6 12 (1 0)	10 15½ (4 2¾)	8 14 (0 4¾)	1 17 (1 18½)	5 12¾ (0 15½)	6 11¾	8 2½ (0 9½)	11 2½ (1 10½)
10	12 tons dung and stan. dress. without nitrogen	4 15½ (0 15¼)	7 19¼ (3 2¾)	5 19¼ (0 5)	2 1 (1 17½)	5 0¼ (0 16½)	3 15¼	8 1 (0 12)	10 13¼ (1 12½)
11	12 tons dung and stan. dress. without phosphoric acid	7 4¼ (1 3½)	9 18½ (2 12½)	6 8¼ (0 7½)	2 17½ (2 8¾)	7 16¾ (0 10½)	4 9¾	7 19¼ (0 6¼)	10 7¾ (1 7¾)
12	12 tons dung and stan. dress. without potash	5 12½ (1 1¾)	10 10 (2 1)	8 19¼ (0 9)	2 4¼ (1 18¾)	7 1¼ (0 8)	3 16¾	6 11¼ (0 10½)	10 5¼ (1 14½)

N.B.—The figures in parentheses show the quantity of small and "seed" potatoes in each case.

The average crops per acre at five centres, with the cost of the manure and other particulars, are given in Table XII. Hoppyland Park, West Shaws, and Mordon House are, for the reasons stated above, not included in this table.

TABLE XII.—POTATO EXPERIMENTS, 1903.

AVERAGE CROP AT FIVE CENTRES, WITH COST OF MANURE AND PROFIT PER ACRE.

Plot.	Manure per acre.	Cost of manure.	Average crop at five centres.		Increase of saleable potatoes, over unmanured plot.	Profit due to manure, potatoes at £3 per ton.
			Saleable.	Small.		
		£ s. d.	T. C.	T. C.	T. C.	£ s. d.
1	No manure	—	2 14¾	1 1¼	—	—
2	Stan. dress. (1⅛ cwt. nitrate, ⅞ cwt. sulph. am., 3 cwt. super., 1 cwt. muriate)	1 18 7	5 9¾	1 4¾	2 15	6 6 5
3	Stan. dress., but with potash as kainit	1 18 10	5 5	1 4½	2 10¼	5 11 11
4	Stan. dress., but with potash as sulphate	1 19 10	5 6¾	1 4¼	2 12	5 16 2
5	Stan. dress. without nitrogen	0 16 3	4 0¼	1 2	1 5½	3 0 3
6	Stan. dress. without phosphoric acid	1 11 1	4 2¼	1 3	1 7½	2 11 5
7	Stan. dress. without potash	1 9 10	3 18¼	1 5¾	1 3½	2 0 8
8	12 tons dung	3 0 0	6 14¼	1 7¾	3 19½	8 18 6
9	12 tons dung and stan. dress.	4 18 7	8 11¼	1 10¾	5 16½	12 10 11
10	12 tons dung and stan. dress. without nitrogen	3 16 3	6 17½	1 2½	4 2¾	8 12 0
11	12 tons dung and stan. dress. without phosphoric acid	4 11 1	8 7	1 4¼	5 12¼	12 5 8
12	12 tons dung and stan. dress. without potash	4 9 10	8 9¾	1 3	5 15	12 15 2

The most necessary class of manure.—One of the chief objects was to find out the most important manurial ingredient for the potato crop. The relative effects of the three classes of manures were as follow:—

Plot.	Manure per acre.	Cost of manure.			Average crop of saleable potatoes at 5 centres.		Increase over unmanured plot.		Profit due to manure, potatoes at £3 per ton.		
		£	s.	d.	T.	C.	T.	C.	£	s.	d.
1	No manure		—		2	14¾		—		—	
2	Complete manure	1	18	7	5	9¾	2	15	6	6	5
5	Same as plot 2, but no nitrogen	0	16	3	4	0¼	1	5½	3	0	3
6	Same as plot 2, but no phosphates	1	11	1	4	2¼	1	7½	2	11	5
7	Same as plot 2, but no potash	1	9	10	3	18¼	1	3½	2	0	8

The results agree with those of previous years as showing the advantage of using a complete manure for the potato crop. As shown above, the omission of any of the three ingredients caused a diminution in the crop. Last year the omission of potash made the greatest difference on the average. But it is to be observed that at Harelow and Broad Oak this year the omission of potash did not cause any serious reduction in the crop. At Ingleton and Raby, on the other hand, especially the former, the crop was strikingly reduced when potash was not supplied in the manure. There can be no doubt that in most cases it is advisable to include potash in a manure for potatoes.

At Harelow and Broad Oak, phosphates proved the most important of all the ingredients; but at the other farms these were less important than potash and nitrogen. With these exceptions, therefore, the results for 1903 confirm those of previous years. Nitrogen was on the average less effective in 1903 than in 1902, but its omission from the manure in both years seriously reduced the profit.

The relative importance of the three manurial ingredients for the potato crop at the five centres included in the averages is shown below :—

Ingleton: **potash,** **nitrogen,** phosphates.
Raby: **potash,** **nitrogen,** phosphates.
Harelow: **phosphates,** **nitrogen,** potash.
Old Burdon: **potash,** **nitrogen,** phosphates.
Broad Oak: **phosphates,** **nitrogen,** potash.

The effect of potash from different sources.—Attention has been called in previous Reports to the difference in the value of the various potash manures for potatoes. In 1902 muriate of potash gave the best results, sulphate of potash came second, and kainit third. The results for 1903 are shown below:—

Plot.	Manure per acre.	Cost of manure.			Average crop of saleable potatoes at 5 centres.		Increase over unmanured plot.		Profit due to manure, potatoes at £3 per ton.		
		£	s.	d.	T.	C.	T.	C.	£	s.	d.
1	No manure		—		2	14¾	—			—	
2	Complete manure with potash as **muriate**	1	18	7	5	9¾	2	15	6	6	5
3	Do. do. with potash as **kainit**	1	18	10	5	5	2	10¼	5	11	11
4	Do. do. with potash as **sulphate**	1	19	10	5	6¾	2	12	5	16	2

These results confirm those of the previous year. The difference between the three manures, however, was much less marked last season than in 1902. Taking the individual farms, sulphate of potash gave much the best crop at Harelow, while it proved of less value than even kainit at Ingleton, Raby, and Broad Oak. It has been suggested that sulphate of potash may give better results in wet and muriate in dry seasons, but the indications so far are that this is not so.

Dung v. artificial manure.—The results from artificials alone, from dung alone, and from the two together were as follow:—

Plot.	Manure per acre.	Cost of manure.			Average crop of saleable potatoes at 5 centres.		Increase over unmanured plot.		Profit due to manure, potatoes at £3 per ton.		
		£	s.	d.	T.	C.	T.	C.	£	s.	d.
1	No manure		—		2	14¾		—		—	
2	Stan. dress., artificials ...	1	18	7	5	9¾	2	15	6	6	5
8	12 tons dung	3	0	0	6	14¼	3	19½	8	18	6
9	12 tons dung and stand. dress.	4	18	7	8	11¼	5	16½	12	10	11

The results for 1903 were not so favourable to artificials as they were the previous season. Dung, on the other hand, gave a bigger profit than in 1902. The season may have had something to do with this, as well as differences in the soil and conditions generally at the various centres where the experiments were conducted. At Old Burdon artificials alone produced a better crop than dung alone, and this was also the case at Mordon House, but here the results were so very erratic that they must not be relied on. The profit from dung alone, in spite of the greater cost of the manure, was more by 52s. per acre than that from the artificial dressing as applied to plot 2.

Dung and artificials together.—It was suggested in the Report for 1902, that where dung could be applied at the rate of 18 tons per acre for potatoes it was not altogether economical to use artificials in addition, but that where not more than 12 tons of dung was applied the results indicated that it would usually be profitable to do so. The results from the combined dressing of dung and artificials last season, as shown in the foregoing table, bear out the conclusions of the previous year. By adding artificials to the value of 38s., the profit was increased by £3 10s. per acre, and last season the plot manured with 12 tons dung and the standard dressing of artificials gave the heaviest yield. It might be supposed that certain ingredients would be of less value when used with dung than when used alone, but it is important to note that a complete dressing of artificials with dung gave on the whole better results at most of the centres last season than partial dressings. The omission of potash, however (plot 12), makes only a slight difference in the crop. Indeed, the profit on this plot, owing to the reduction in the cost of the manure, is greater than on plot 9.

The profit results.—The potatoes are valued at £3 a ton, whereas the swedes are valued at 8s. a ton. By doing so a much greater profit is shown from the former than from the latter. The cost of producing and marketing the potato crop, however, is much greater than that of swedes. The former also has a comparatively high value as a saleable crop, while the latter is taken at its consuming value on the farm. This will explain the apparent discrepancies in the results of the two crops.

CONCLUSIONS.

(1) During 1903, potash has proved in the majority of cases to be the most important ingredient in manures for potatoes, and muriate of potash proved the most satisfactory potash manure. These results are in accordance with previous experiments.

(2) Nitrogen in all cases proved of great value, and should be included in all artificial mixtures for this crop.

(3) Phosphates, although generally of less importance than potash and nitrogen for potatoes, are necessary on certain classes of soils.

(4) When artificials are used alone, it is best to apply a "complete" dressing, with the various ingredients in a somewhat similar relative proportion to those in the standard dressing applied to plot 2.

(5) Dung alone, as was the case last year, gave better results than artificials alone, but their relative effects will depend largely upon circumstances.

(6) As a rule it is profitable to use dung and artificials together in moderate quantities, and on the whole this may be regarded as the most economical method of manuring the potato crop. This was done on plot 9 last year, and the results were satisfactory.

(7) As dung varies so much in composition, it is safest in the majority of cases to use "complete" artificials along with it, although nitrogen appears from last year's results to be more important in this connection than the other ingredients.

EXPERIMENTS ON THE MANURING OF MANGELS.

Experiments on the manuring of mangels were conducted last season at six centres, five in the county of Durham and one in Northumberland. The results from three of the stations only are tabulated, as the crop at the others was a failure. The names of the three centres and particulars of the soil are as follow:—

CENTRES FOR MANGEL EXPERIMENTS.

No.	Centre.	Owner or Occupier.	Soil and geological formation.	Previous crop and manuring.	Variety grown.
1	Broomhaugh, Riding Mill	Mr. C. Marshall	Very stony sandy loam on the Glacial Sands and Gravels	Oats; no manure. Turnips in 1901	Hirst's Monarch
2	Raby Home Farm	Rt. Hon. Lord Barnard	Rather strong loam on Boulder Clay	Barley, following swedes	Darlington Globe
3	Middleton House, Gainford	Mr. T. S. Todd	Clay loam of good quality on Boulder Clay	Oats, with 3 cwt. per acre dissolved bones	Darlington Globe

TABLE XIII.—EXPERIMENTS ON THE MANURING OF MANGELS, 1903.

PLOTS 1/27-ACRE. RESULTS PER ACRE.

The standard dressing of artificials consists of 1⅛ cwt. nitrate, ⅞ cwt. sulphate of ammonia, 4 cwt. superphosphate, and ¾ cwt. muriate of potash. This contains 40 lb. nitrogen, 50 lb. phosphoric acid, and 40 lb. potash.

Plot.	Manure per acre.	Cost of manure per acre.			Produce per acre.					
					Broomhaugh.		Raby.		Middleton House.	
		£	s.	d.	T.	C.	T.	C.	T.	C.
1	No manure		—		14	17½	9	0	4	11¾
2	Stan. dress. and 3 cwt. salt	2	1	10	14	16	12	6¼	9	5½
3	Stan. dress., but half the nitrate top-dressed 3 or 4 weeks after singling	1	18	10	9	9½	12	15	8	11¾
4	Standard dressing	1	18	10	13	0	16	0	8	3½
5	Stan. dress. without nitrogen ..	0	16	6	12	10	9	7½	6	10½
6	Stan. dress. without phosphoric acid	1	8	10	12	7½*	12	15	9	2¼
7	Stan. dress. without potash	1	12	4	13	11¾*	14	10	8	8½
8	12 tons dung	3	0	0	12	0	15	10	10	11
9	12 tons dung and stan. dress. ...	4	18	10	17	18¼	18	10	13	16
10	12 tons dung and stan. dress. without nitrogen	3	16	6	17	5½	12	15	10	7½
11	12 tons dung and stan. dress. without phosphoric acid	4	8	10	9	8¾	16	10	12	15½
12	12 tons dung and stan. dress. without potash	4	12	4	15	1¼	19	0	12	14¼

* The mangels grown on these two plots were of a different variety from those grown on the other plots.

Objects.—These were:—(1) To ascertain the most suitable artificial manures for this crop with and without dung; (2) to test the value of salt as a manure for mangels; and (3) to indicate the most profitable method of applying nitrate of soda.

Results.—The plan of manuring adopted, and the results obtained at the three centres are shown in Table XIII. They are somewhat erratic, and it is quite impossible to draw from them any general conclusions. The crop was in no case a heavy one. Taking the average, it was heaviest, though only slightly so, at Raby. Good crops were produced on several of the plots at Broomhaugh, one of the best being the unmanured plot, a fact which makes this centre, interesting in many ways, useless for purposes of comparison. The first point of interest in connection with the other two centres is the effect of omitting nitrogen from the manure. It has long been known that this ingredient is of special value for the mangel crop in the majority of cases, and this is borne out in the two under notice. The results on plots 3 and 4 are not conclusive as to whether the whole of the nitrate of soda should be applied in the drill, or partly in the drill and partly as a topdressing after singling. The topdressing of nitrate appears to have increased the crop at Middleton House by 8¼ cwt. as compared with plot 4, where all the nitrate was applied in the drill. But at Raby, on the contrary, there was a much better crop where the whole of the nitrate was applied at the same time as the other manures. Phosphates and potash appear to have been almost useless for mangels at both centres. The relative importance of the three valuable ingredients in manures for mangels at the two stations was as follows:—

Raby :	**nitrogen,**	**phosphates,**	potash.
Midddleton House :	**nitrogen,**	**potash,**	phosphates.

The most important ingredient, as already shewn, was nitrogen. The other two ingredients might, apparently, have been omitted altogether at these two places without lessening the crop.

Salt did not prove useful at Raby. At Middleton House it gave an increase more than sufficient to cover the cost.

Variations in the Composition of Milk, and their Probable Causes.

An inquiry into the variations in the composition of milk by the Agricultural Department of the Durham College of Science has been in progress since January 1st, 1903. At the request of the Northumberland County Council, the College undertook to make these investigations of a more thorough character, and to extend this work in that county.

A large number of samples of milk of individual cows and of mixed milk have been collected from different farms, and the amounts of butter fat and of solids not fat contained therein have been estimated. The breed of the cows, the times of milking, the weather conditions, the temperature outside and inside the cowsheds, and the daily rations fed to the cows, have all been noted. **Mr.** James **McLaren,** Offerton Hall, and **Mr.** Charles **Marshall,** Broomhaugh, both placed their herds at the disposal of the College, and samples of milk from individual cows and from the mixed milk of these herds have been taken fortnightly and tested at the College. Samples have also been taken and tested from cows on the Duke of Northumberland's Home Farm, Alnwick, and from the herd of **Mr.** J. Swann, Lookout Farm, Seaton Delaval. As changes in the composition of milk of individual cows occur very quickly, the milk of one cow has been regularly tested at Cockle Park during the greater part of 1903, so that their extent might be noted.

Sampling and testing.—The proper sampling of milk for testing is very difficult. Every care was taken that all the first drawn milk and all the strippings were included in the bulk from which the sample was taken, as the former is very poor, and the latter very rich, in butter fat. Each lot of milk was thoroughly mixed before the sample was taken, and this was taken from the middle of the bulk, this precaution being necessary, as cream soon begins to rise to the surface. The samples have nearly all been taken by Dr. Potts, Mr. R. R. Swann, B.Sc., Mr. Geo. Willis, and Mr. James McLaren, jun.

All the samples of milk from Offerton and Broomhaugh have been tested by Mr. S. H. Collins, the College Lecturer in Agricultural Chemistry. Those at Cockle Park were tested by Mr. J. H. J. Farquhar, B.Sc.; at Seaton Delaval by Mr. R. R. Swann, B.Sc.; and at Alnwick by Mr. A. W. Patten. In all cases the fat was ascertained by the Gerber butyrometer; and from this and the specific gravity the solids not fat were calculated. Mr. Collins checked his results by other analytical methods.

Mr. W. J. Lawrence, the manager of the Cumberland and Westmorland Farm School, has placed the results of a year's tests of the school herd at the disposal of the College.

OFFERTON RESULTS.

At Offerton, the milk of each of twelve cows was tested once a fortnight, from January 10th till March 21st, 1903. The cows had all calved between July 19th and December 20th, 1902. They were milked three times a day, at 5 a.m., 1 p.m., and 6 p.m., the intervals being therefore 11, 8, and 5 hours. The amount of milk given by each cow averaged about 11½ pints in the morning, 7 pints at mid-day, and 4 pints in the evening, this being equivalent to about 2¼ gallons per cow daily. The milk is all retailed in the Sunderland district. Each cow received daily 100 lb roots, 8 lb hay, 10 lb cake and meal, and as much oat straw as she would eat. They were either not turned out at all or for about half an hour only. The cows were all ordinary shorthorns and fairly representative of the herd of over fifty cows.

TABLE XIV.—OFFERTON DAIRY HERD. COMPOSITION OF MIXED MILK OF TWELVE COWS (CALCULATED).

Date.	Fat.			Solids not fat.			Pints.			Weather conditions.
	M.	N.	E.	M.	N.	E.	M.	N.	E.	
1903. Jan. 10 ..	3·03	4·03	4·02	9·36	9·17	9·43	135	85	48	Mild, wet sleet later, strong N. wind.
,, 24 ..	3·62	4·46	4·53	8·76	9·03	9·26	148	87	37	Fine day, mild previous evening.
Feb. 7 ..	3·33	4·31	4·39	8·82	8·83	9·13	143	87	46	Fine morning, wind and gale later.
,, 21 ..	3·30	4·22	4·21	8·91	9·07	9·11	135	80	42	Windy, fair morning, rain later.
Mar. 7 ..	3·60	4·24	3·89	8·97	9·05	9·28	133	64	40	Fine after frosty night.
,, 21 ..	3·32	4·30	3·95	8·84	8·88	9·06	136	70	47	Mild and windy.
Average ..	3·36	4·26	4·16	8·91	9·00	9·21	138	79	43	

Mixed milk.—More milk was produced in the first milking than in the last two taken together. The solids not fat tended to increase during the day; and the fat percentage was much higher (nearly 1 per cent.) at mid-day than in the morning, but not higher for the third milking than for the second, though the interval before the third is three hours less, and the quantity is less at this time. The cows, however, were not milked so clean in the evening, and this probably explains the results. Had a third milking not been done each day it is probable that the morning's milk would have occasionally contained less than the standard of fat. In no case did the fat or solids not fat fall below the standard, but the fat varied considerably within a fortnight in some cases.

Individual milk.—The milk of the individual cows showed great variation. Two hundred and sixteen tests were made, with the following results:—Morning's milk, 72 tests, 15 tests under standard of 3 per cent. fat, 1 test under standard of 8·5 per cent. solids not fat; noon's milk, 72 tests, 0 do., 0 do.; evening's milk, 72 tests, 6 do., 0 do. The milk of the individual cows varied considerably in quantity, but increase in quantity did not usually mean a falling off in quality nor *vice versa*.

In the case of the mixed milk, the largest quantity of morning milk produced (Jan. 24th) was also the richest in fat, while the smallest quantity of noon milk (March 7th) was poorest in fat.

BROOMHAUGH RESULTS.

At Broomhaugh, the milk of each of twelve cows has been tested as at Offerton, but the tests have been continued each fortnight throughout the whole of 1903. The cows have not been the same throughout, as none of them continued in milk for this period. The times of milking were 5·30 to 6·30 a.m., and 4 to 5 p.m. The cows were all shorthorns, from a herd consisting of from thirty-six to thirty-eight cows. The milk was all sent off by rail.

Mixed milk.—The mixed milk was under the standard of fat once only, viz., on the morning of September 24th, when the fat percentage was 2·8. The solids not fat were five times just under the standard in the evening, being only so in July and August; and once in November they were as low as 8·2 per cent. in the morning's milk. The effects of indoor and pasture feeding were as follows:—Average fat in milk: winter feeding indoors, 12 tests, morning, 3·7 per cent.; evening, 4·0 per cent. Pasture feeding outdoors, 9 tests, morning, 3·4 per cent.; evening, 4·1 per cent. These averages show that the milk at Broomhaugh was practically as rich in fat during the summer as during the winter, and thus it differed materially from that at Newton Rigg. The cows at the latter place received no concentrated food during the first two months on pasture, and only from 1½ lb to 2 lb daily during the remaining three months, but those at Broomhaugh received from 5 lb to 8 lb concentrated food daily all the time they were on pasture, and it looks as if this concentrated food, in addition to the grass, has maintained the summer milk at Broomhaugh up to the standard of that of the winter. The quantity of milk given

TABLE XV.—BROOMHAUGH DAIRY HERD. COMPOSITION OF MIXED MILK OF TWELVE COWS (CALCULATED).

Date.	Fat.		S.N.F.		Pints.		Outside temperature.		Time out of doors.	Daily ration.*	Weather conditions.
	E.	M.	E.	M.	E.	M.	12 hours previous to E.	12 hours previous to M.			
1903.											
Jan. 14 ..	4·3	3·7	8·8	9·1	9	9½	21	22	Half-an-hour for water	10 lb. cake and meal, 21 lb. swedes, 17 lb. hay	North-easterly breeze.
,, 28 ..	3·8	3·8	8·7	8·7	8	9½	44	38	,, ,,	,, ,, ,,	Fine, mild.
Feb 12 ..	3·8	3·7	8·6	8·8	8	9	..	54	,, ,,	,, ,, ,,	W. wind, fair.
,, 26 ..	3·8	3·6	8·87	9·0	8	10½	38	38	,, ,,	,, ,, ,,	,, ,,
Mar. 12 ..	4·0	3·8	8·7	9·0	10	11½	36	42	,, ,,	,, ,, ,,	Fair, very little wind.
,, 26 ..	4·5	3·9	8·5	8·8	7	9	45	52	,, ,,	,, ,, ,,	Mild, S.W. wind.
April — ..	..	..	..	..	..	..	..	..	....	....	....
,, 23 ..	4·3	3·4	8·7	8·8	9¾	11	31	40	2 hours	10 lb. cake and meal, 21 lb. swedes, 17 lb. hay	Fine warm day, N. wind.
May 7 ..	3·8	4·3	8·9	8 8	11¼	13¼	..	49	8 hours: on grass	11½ lb. cake and meal, 20 lb. mangels, 7 lb. hay, and pasture	N. wind.
,, 21 ..	3·7	3·8	8·8	8 7	11½	12½	34	55	10 ,, ,,	,, ,, ,,	Gentle breeze from S.W.
June 4 ..	4·0	3·5	8·8	8·7	11¼	11¾	..	57	All day and night	Pasture and 8 lb. cake and meal ..	Calm.
,, 18 ..	3·5	3·6	8·7	8·7	9¾	10¾	47	49	,, ,,	Pasture, 5 lb. cake and meal, cut grass and clover	Slight W. breeze, with rain.
July 9 ..	4·4	3·3	8·4	8·6	9¼	9½	..	65	,, ,,	,, ,, ,,	Wind N.W. as a whole, but very changeable.
,, 23 ..	3·7	3·5	8·49	8 6	8	8¾	56	66	,, ,,	Pasture, 6 lb. cake and meal, cut grass and clover	Calm.
Aug. 6 ..	4·5	3·6	8·4	8·6	8½	8½	..	63	,, ,,	Pasture, 8 lb. cake and meal, new hay ..	Strong W. wind, showery.
,, 28 ..	4·6	3·6	8·49	8·5	8	8¾	52	64	,, ,,	,, ,, cut clover	Mild, with showers.
Sept. 10 ..	4·3	3·6	8·6	8·8	8¼	9	..	51	,, ,,	,, ,, ,,	Cold N.W. wind, very humid.
,, 24 ..	4·0	2·8	8·5	8·6	7¼	8½	43	68	,, ,,	,, ,, ,,	Dull, close day.
Oct. 8 ..	4·1	3 7	8·4	8·5	7½	8	..	52	,, ,,	,, ,, ,,	W. wind, with rain.
,, 22 ..	4·6	3·3	8·5	8·7	8½	8½	..	48	8 hours, in at night	,, ,, ,,	,, ,,
Nov. 5 ..	4·0	3·5	8·6	8·2	7¼	8	43	46	8 ,, ,,	Pasture, 8 lb. cake and meal, cut clover, turnip tops	,, fine.
,, 19 ..	4·0	3·7	8·9	9·1	7	9	..	34	6 ,, ,,	28 lb. white turnips, 6 lb. hay, 6 lb. cake and meal	Fine and cold.
Dec. 3 ..	4·1	4·2	9·1	8·8	6¾	9	..	29	5 ,, ,,	28 lb. swedes, 12 lb. hay, 6 lb. cake and meal	,, ,,
,, 17 ..	4·4	3·6	9·2	9·3	6¾	7¾	32	37	5 ,, ,,	,, ,, ,,	Dull and close, with rain.

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* In addition to straw *ad lib.* Heavy milkers get in addition a mash made of 7 lb. of a mixture of oat dust, dec. cot. cake meal and maize meal.

on the average by each cow was as follows:—During winter, morning, 10 pints; evening, 8¾ pints. During summer, morning, 9¼ pints; evening, 8½ pints. The twelve cows therefore produced an average of 2¼ gallons milk daily. The amount of fat generally shows considerable variation from fortnight to fortnight, especially in the evening's milk.

Individual milk.—The milk of the individual cows again showed great variation here. Five hundred and four tests were made, with the following results:—Morning's milk (252 tests), 40 tests under standard of 3 per cent. fat; 46 tests under standard of 8·5 per cent. of solids not fat. Evening's milk, (252 tests), 17 tests under standard of 3 per cent. fat; 62 tests under standard of 8·5 per cent. of solids not fat. Here also increased quantity did not usually mean a falling off in quality. Some striking variations occur in the milk of the cows at Broomhaugh that are evidently due to the individual characteristics of the cows themselves. The yield and amount of fat in the milk of a cow called "Fidget" was extremely variable; this cow was quick-tempered and very excitable. Two cows called "Slaggy" and "Ruth" were of quiet and peaceful dispositions, and the milk of these cows was very even, both in quality and quantity. Another cow, "White Rose," was quiet, but she allowed her milk to run from the udder, and in this case the amount of fat was variable.

Results at Seaton Delaval.

The mixed milk of six grade shorthorn cows was tested daily from March 4th till May 12th, 1903. They were all of a good size, and were useful breeding animals, but not heavy milkers. Two of the cows had calved recently, and other two were nearly at the end of their lactation period, but one of the latter was replaced on March 23rd by a pure bred shorthorn cow; the other was dried off on April 1st, and her place was taken on April 9th by a recently calved Irish heifer. The cows were milked twice a day, at 6 a.m. and 4·30 p.m.

TABLE XVI.—DAIRY HERD AT SEATON DELAVAL. COMPOSITION OF INDIVIDUAL MILK.

Date of Sampling.	Cow (2).				Cow (3).				Cow (5).				Cow (6).				Cow (7).				Cow (8).				Cow (4).				Cow (1).			
	Fat.		Pints.		Fat.		Pints.		Fat.		Pints.		Fat.		Pints.		Fat.		Pints.		Fat.		Pints.		Fat.		Pints.		Fat.		Pints.	
	M.	E	M	E.	M.	E.	M.	E.	M.	E.	M.	E.	M.	E.	M.	E.	M.	E.	M.	E.	M.	E.	M	E.	M.	E.	M.	E.	M.	E.	M.	E.
1903. March 5th ..	2·8	2·8	13	10	3·5	4·1	15	12	3·4	3·7	13	11	3·6	4·0	12	9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ 20th ..	3·2	3·2	12	11	3·5	4·3	13	10	3·5	3·5	13	9	3·6	4·7	12	10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
April 9th ..	3·6	3·2	12	10	3·7	3·4	13	10	5·6	3·2	8	7	4·0	4·6	13	11	3·5	4·6	8	6	..	..	..	..	..	..	..	..	..	..	..	..
„ 23rd ..	2·8	2·9	10	9	4·0	4·0	12	10	3·8	3·2	12	9	3·6	4·0	10	9	3·5	4·3	7	6	..	..	..	..	..	..	..	..	..	..	..	..
May 8th ..	3·4	4·7	10	8	3·9	4·1	11	10	3·9	3·5	14	13	4·7	4·6	13	10	4·5	3·7	7	6	3·6	3·7	21	18	3·7	4·3	16	19	4·3	5·0	19	13
„ 22nd ..	2·6	4·5	7	7	3·2	4·0	14	12	3·6	5·1	14	12	3·4	4·5	14	11	3·4	4·7	8	6	3·7	4·0	20	17	4·2	4·4	21	15	3·7	4·1	19	16
June 4th ..	2·6	2·2	7	7	4·2	4·3	15	11	3·7	4·0	12	10	4·1	4·3	14	10	3·1	4·1	8	3	3·3	3·5	19	18	3·4	3·5	23	18	5·5	5·6	15	12
„ 18th ..	3·6	5·1	2	7	2·7	3·5	13	11	3·8	4·4	12	8	4·9	6·6	13	9	3·8	4·0	7	6	2·0	4·5	18	18	3·9	4·2	24	18	3·7	5·1	16	13
July 2nd ..	2·0	3·5	4	4	3·9	5·0	14	10	4·0	4·8	8	8	4·2	5·2	10	8	4·0	3·8	7	6	4·2	4·5	17	13	3·8	4·2	19	19	4·1	4·4	13	12

TABLE XVII.—DAIRY HERD AT SEATON DELAVAL. COMPOSITION OF MIXED MILK.

Date of Sampling.	Weather.	Wind.	Outside temperature.		Mixed milk.					
			Twelve hours previous to Morning.	Twelve hours previous to Evening.	Fat.		S.N.F.		Pints.	
					M.	E.	M.	E.	M.	E.
1903.			F.	F.						
March 5th ..	Dry, cold	Strong	44°	34°	3·3	3·7	8·80	8·66	57	46
„ 20th ..	Fine	Moderate	50°	49°	3·5	3·8	8·84	8·68	52	42
April 9th ..	Dry, mild	Strong	58°	52°	3·8	3·8	8·90	8·68	65	54
„ 23rd ..	Mild, after severe frost and snow	Light	48°	48°	3·4	3·8	8·82	8·65	63	53
May 8th ..	Fine, after much rain	Calm	54°	50°	3·9	4·1	8·92	8·71	111	97
„ 22nd ..	Warm, nights colder	Calm	61°	51°	3·4	4·4	8·82	8·77	117	96
June 4th ..	Very warm	Calm	69°	60°	3·6	3·9	8·86	8·67	113	89
„ 17th ..	Fine, after cold, wet night	Light north wind ..	..	47°	3·4	4·6	8·57	8·56	105	30
July 2nd ..	Warm, dry	Light south wind ..	70°	60°	3·6	4·4	8·86	8·77	92	80

Mixed milk.—During the whole period (seventy days) the solids not fat were remarkably constant, their limit of variation being from 9·1 to 8·5 per cent., and on only one occasion were they as low as the 8·5 per cent. standard. They were almost invariably rather lower in the afternoon's than in the morning's milk. The butter fat also was never once under the standard (3·0 per cent.) during the whole of this time, either in the morning or afternoon. The extreme limits were 3·1 to 4 per cent. in the morning, and 3·5 to 4·9 per cent. in the evening. The greater variation in the afternoon is probably due to the greater liability of the cows to be exposed to exciting conditions during the day. The cows were in at night for the whole time except for the last four evenings, and were thus protected from exciting conditions and weather changes during the night. During the whole seventy days the average amount of fat was 3·55 per cent. in the morning and 4·09 per cent. in the afternoon. The yield of milk of all the cows varied from 6 to 8 gallons in the mornings, and from 5 to 6¾ gallons in the afternoons. The intervals between milking were ten and a half hours during the day and thirteen and a half hours during the night. The shorter interval before the afternoon's milking was the main cause of the milk being less in quantity and richer in fat at this time.

Weather effects.—A strong west breeze was blowing on March 4th and 6th, but this moderated on the 7th, and the fat contents of the milk increased 1·1 per cent. that afternoon over that of the previous afternoon. The cows had been out about five hours on each of these days. On April 5th and 8th there was comparative calm after wind, and on each of these days the afternoon's milk had ½ per cent. more butter fat. On April 11th a strong north-west breeze was blowing, and the fat went down by ·3 per cent. A cold north wind continued till April 18th, accompanied by a considerable drop in the fat of the afternoon's milk on many of the intervening days, although there was an unaccountable rise of 1 per cent. of fat during one of them. On April 19th a calm day followed and the fat increased. The fluctuations in percentage of fat were greatest during the cold weather with north winds between April 11th and 25th. Wet weather with no wind followed till May 6th, during which time the afternoon's milk had more fat and less variation in amount. The cows were usually turned out five to six hours a day from March 4th till May 8th. They were turned out for about half that time on April 12th to 15th, and on May 2nd, 3rd, and 6th. On five of these seven days the afternoon's milk had an increased amount of butter fat, and this may have been prevented by the severe weather of the remaining two days. On May 22nd the evening's milk was 1 per cent. richer in fat than that of the morning, this being a warm day after a cold night. Apparently the cold night reduced the fat percentage of the morning's milk, but the warm day which followed considerably increased it. On June 18th, when it was fine after a cold, wet night, there was 1·2 per cent. more fat in the evening's than in the morning's milk—a similar result to what had taken place on May 22nd. Again, on April 9th, a strong wind was blowing when the cows were turned out during the day, and this may be the cause of the evening's milk being no richer on that day than that of the morning. On June 4th the weather was very warm, and the evening's milk was very slightly richer in fat than that of the morning, which may be due to the effect of the heat on the cows. The cold, wet night of June 17th affected the milk of cow No. 1, by greatly reducing the quantity of her morning's milk, while the fat percentage in the milk of cow No. 8 was reduced very largely on the same morning.

Change of food.—The cows were turned out at night on and after May 9th, and their milk was tested till May 12th. The weather was fine and the evenings were mild. They received grass only after being turned out. Notwithstanding this complete change of conditions there were practically no changes in the quantity or quality of the milk. From March 4th till 10th each cow received daily 86 lb mangels, 20 lb hay, and 10 lb linseed cake. On March 11th a compound cake replaced the linseed cake, with no change in the quantity or quality of the milk. On March 24th, 6 lb of another compound cake with 4 lb of maize and oatmeal were given, and still there was no change in the milk. The quantity of mangels given was reduced to 50 lb per cow daily on April 23rd, but the quantity and quality of the milk produced by the cows were not reduced thereby. Nor was this so when the mangels were withdrawn altogether on April 30th. When the mangels were stopped the cows would have remained out all day if the weather had been fair, but as wet weather followed, they were out only for the same time as before.

Individual milk.—The individual milk, as well as the mixed milk, of 6 to 8 cows was tested once every fortnight from March 5th till June 18th, 1903. The solids not fat were in eighteen instances under the 8·5 per cent. standard out of 128 tests of the milk of the individual cows. They were always above the standard in March and April. The cases when they were under standard occurred in May, June, and July. At no time did the fat or solids not fat fall below the standard in the mixed milk. Two cows of a nervous temperament gave milk in which the fat varied considerably. Frequently when the cows gave more milk it had more fat, and when they gave less milk it had less fat.

ALNWICK RESULTS.

The mixed milk of three shorthorn cows was tested daily at the Duke of Northumberland's Home Farm, from March 19th till April 20th, 1903. The three cows were from five to nine years old, and calved on January 5th, February 7th, and February 27th respectively. One was a pedigree and two were non-pedigree animals, the latter being purchased for rearing calves. They were milked at 6 a.m. and 6 p.m. They gave on the average nearly 5 gallons of milk in the morning and about 4 gallons in the evening (an average of 3 gallons a cow daily), so that with equal time between milking the morning quantity was greatest. The morning's milk was fourteen times, and the evening's milk seven times, under the fat standard during thirty-three days. The fat in the morning's milk varied from 2·15 to 4·25 per cent., and in the evening's from 2·45 to 4·35 per cent.

Effects of weather.—The cows were turned out from 11 to 1 o'clock daily after March 24th. The milk had more fat for a few days afterwards, but a reaction followed, as the poorest milk was given on the last three days of March. The weather was not colder, but a strong wind on March 28th and 29th may have upset the cows and reduced the fat in the milk. The milk of each of these cows was tested on April 2nd and 17th. On the first morning the milk of each cow was under the fat standard, one having less than 2 per cent. of fat. A strong north-west wind was blowing during that and the previous day, which, as all the cows were affected, probably reduced the fat in the milk. On April 17th the cow that had previously given milk with less than 2 per cent. of fat now gave the same with over 4 per cent. of fat, while the milk of the others was also better. The evening's milk of two of the cows was poorer on that day than that of the morning; this was probably caused by the wind changing to the north on that day. On seven of ten days that the wind changed to the north the evening's mixed milk was poorer than that of the morning, the reverse being the normal condition.

The milk contained 1·55 per cent. less fat on the morning of the 14th than on that of the 13th, and 1·45 per cent.

less on the morning of the 17th than on that of the 16th. This was probably caused by the severe weather. The cows were not turned out for the customary two hours on the days when snow fell, which probably increased the fat in the evening's milk of these days, but when turned out on the following days, when cold winds prevailed, the fat was very much reduced, probably as a result. The figures show that the milk was frequently poorest in fat in the evening during the severe weather, whereas during the preceding genial weather the opposite was the case. The results show how great the variations in the amount of fat may be in the milk of a few cows, and how much these variations may be increased by severe and changeable weather; they also show that a small number of cows receiving fair feeding and attention may frequently produce milk which is under the standard. Even though the intervals between the milkings were equal, the morning's milk has been greater in quantity and poorer in butter fat than that of the evening. The cows each received daily about 5 lb linseed cake and meal, 20 lb roots, and as much hay and straw as they would eat.

COCKLE PARK RESULTS.

Regular tests of one cow's milk have been made daily from January till October, 1903, mainly with the object of noting the changes from day to day, and comparing these changes with the meteorological conditions of which a complete record is kept. The milk of a grade shorthorn cow (No. 3) was tested from January 1st till April 23rd. She had probably some Channel Islands blood, was six years old, had calved her third calf in the last week of October, 1902, and was of a quiet and docile disposition. She was milked at about 6 a.m. and 4·15 p.m. on week days, but half an hour later in the afternoons during April, and on Sundays at 8 a.m. and 4 p.m. She received from 5 lb to 8 lb daily of cake and meal with hay and water. She was turned out when weather permitted from 9·30 a.m. till 3·30 p.m. The following table shows the limits of variation of the milk of this cow:—

	Jan.	Feb.	March.	April.
Per cent. of fat—				
Morning	3·8—5·3	3·8—5·0	3·5—7·1	4·1—5·2
Afternoon	4·8—7·3	5·1—7·5	4·7—7·8	4·7—6·9
Per cent. of solids not fat—				
Morning	8·3—9·4	8·3—9·3	8·3—9·4	7·9—9·6
Afternoon	7·3—9·6	7·0—9·5	7·8—9·3	8·3—9·2
Quantity (lb.)—				
Morning	9—12	7—11	5—10	5—7
Afternoon	3—6	3—7	3—6	4—7

The milk of this cow never contained less than 3·5 per cent. of fat during this time, and it actually was as high one afternoon as 7·8 per cent. The milk was considerably richer in fat in the afternoon than in the morning, and the variations in fat were greatest in the afternoon. The greatest variations took place as follows:—

	Thurs., Mar. 19.	Fri., Mar. 20.	Sat., Mar. 21.	Sun., Mar. 22.	Mon., Mar. 23.
Per cent. of fat—					
Morning	5·0	4·7	7·1	3·6	4·7
Afternoon	5·3	7·3	7·8	5·4	6·2
Quantity (lb.)—					
Morning	7	5	6	5	7
Afternoon ...	5	6	4	4	5

The causes of these have not been ascertained. So far as can be judged the weather was not accountable. The solids not fat have been very frequently considerably under the standard. When this cow was in season, on April 12th, neither the quantity nor the quality of the milk was materially affected. On the whole, the milk on Sunday afternoons was rather richer, because of the shorter interval between the milkings on that day, and Monday morning's milk was rather poorer for the opposite reason.

The milk of a small red shorthorn cow (No. X) was tested from the beginning of May till the end of October. She calved (her third calf) on May 3rd. This cow is also quiet and good tempered. She was out at night from June 4th till October 8th. She received 6 lb to 8 lb cake and meal daily during the whole period, and was milked as follows:—May and June, 8 a.m. and 6 p.m.; July and August, 7 a.m. and 6 p.m.; September and October, 7·30 a.m. and 5 p.m.; but on Sundays during the whole period, 8 a.m. and 4 p.m.

During one hundred and sixty-five days the solids not fat were fifty-eight times under the 8·5 per cent. standard in the morning, and fifty-seven times in the evening. These were higher during September and October, but lower and more variable during June, July, and August. The limits of variations in solids not fat were:—In morning, 7·08 per cent. on July 2nd and 9·83 per cent. on October 10th; in evening, 7·00 per cent. on July 1st and 9·52 per cent. on October 9th. During the same time the fat was thirty-five times under the 3 per cent. standard in the morning and twenty times in the evening. This cow has very frequently had less fat in her milk in the evening than in the morning, and had less fat on the average during July than during the other months.

The fat in the evening's milk was very low after the hot day on July 1st and after the thunderstorm on July 2nd. Great and sudden variations occurred throughout the whole period. Cold nights occurred in June, at which time the morning milk was usually much poorer than that of the evening, but during the fine days in July the reverse was usually the case. This cow gave about 4 gallons a day for the first three months, but less during August, about 3 gallons a day during September, and about 2 gallons a day during October. Sunday evening's milk was usually rich in fat, because of the short day interval, but Monday morning's was usually poorer and greater in quantity. On Thursday morning, September 10th, this cow produced 16 lb of milk, with 1·1 per cent. of fat, and on the following morning 19 lb of milk, with 6·8 per cent. of fat. The first of these was preceded by a cold and wet evening, while the following was a better night. Evidently, therefore, the poorer milk was caused by the cow being upset by exposure during a bad night, after which a big reaction followed. Tuesday, July 14th, was a hot day, and that evening the cow gave rather less milk with only 1·8 per cent. of fat, whereas the milk of the previous evening had contained 4·6 per cent. of fat. When this cow was in season on June 10th, the morning's milk contained 1·5 per cent. of butter fat only, although the quantity was not reduced.

NEWTON RIGG RESULTS.

Mixed milk.—The milk of seventeen cows was tested for fat once a month during one year. Milking took place at 6 a.m. and 5 p.m. The following average results, which compare the effects of indoor and pasture feeding, are interesting:—

	Average fat in milk.	
	Morning.	Evening.
December, 1902, to April, 1903 (cows indoors)	3·8 %	4·2 %
May to October, 1903 (cows on pasture) ...	3·5 %	3·6 %
November, 1903 (cows indoors)	3·6 %	3·7 %

It will be seen that during the winter months the milk contained much more fat, and also that the evening's milk was relatively much richer, when the cows were indoors than when they were on pasture. The morning's milk on September 15th had just the standard amount of fat (3 per cent.). The table of results shows that in all other cases it was well above the standard. The solids not fat (calculated from individual samples) were well over the standard during most of the year, especially during the first six months. They were lowest in the autumn, and were only just above the standard on the evening of August 15th.

Individual milk and variation in age.—The milk of each of the seventeen cows was also tested once a month for fat and for solids not fat. Four of the herd were in milk after their first calf. These gave about 1 gallon of milk

TABLE XVIII.—NEWTON RIGG DAIRY HERD. COMPOSITION OF MIXED MILK OF 17 COWS (ANALYSED).

Date.	Fat		Daily ration.	Weather conditions.	
	M.	E.		Previous evening.	Same day.
1902. Dec. 15th ..	4·0	4·2	8 lb. cake and meal, 42 lb. swedes, one foddering hay, two fodderings straw	Very wet	Very wet and strong wind.
1903. Jan. 15th ..	3·9	4·0	,, ,, ,,	Very hard frost	Very hard frost.
Feb. 14th ..	3·3	3·9	,, ,, ,,	Frost	Dull, with a little rain, milder.
Mar. 14th ..	4·0	4·3	,, ,, ,,	Cold and fine	Cold and wet.
Apr. 15th ..	3·6	4·4	Same, except 28 lb. mangels instead of swedes	Cold N. wind, storms, a little snow ..	Cold N. wind and storms.
May 15th ..	3·3	3·7	,, ,, ,,	Fine but cold. (Cows out on grass; their first week)	Fine, but cold.
June 15th ..	3·6	3·7	On grass day and night, no other food ..	Fine and not cold	Drizzling rain, not cold.
July 15th ..	3·7	3·5	,, ,, ,,	Very wet	Very wet.
Aug. 15th ..	3·4	3·4	1½ lb. dec. cot. cake since July 20th ..	Mild, some rain	Mild, showers.
Sept. 15th ..	3·0	3·8	2 lb. dec. cot. cake since August 21st ..	Fine, S.E. wind, bright sunshine (a fine week)	Fine, S.E. wind, bright sunshine.
Oct. 15th ..	3·9	3·8	,, ,, ,,	Mild and wet	Mild and wet.
Nov. 14th ..	3·6	3·7	Winter ration as in December	Wet and rather cold. (Cows indoors) ..	Wet and rather cold.

Milking time at 6 a.m. and 5 p.m. all the year round.

each in the morning and ¾ gallon in the evening, for three or four months, and continued in milk for from five to eight months. Their milk contained the high average of about 4 per cent. of butter fat, and in no case was it under the standard. Five of the cows were in milk after their second calf. These gave about 1½ gallons in the morning and about 1¼ gallons in the evening for the first few months. Their milk contained about 3·6 per cent. of fat on the average, and in only four cases was it under the standard. Seven of the cows were milking after their third and fourth calves. These gave for some time after calving about 1¾ gallons in the morning and 1½ gallons in the evening. The average fat contents of their milk was about 3·4 per cent. A cow in milk after her seventh calf gave results very similar to the foregoing.

In nearly two cases out of three there was more fat on the evening's than on the morning's milk given by the individual cows. It is evident from the great variations that occurred that the amount of fat in the milk of any cow may be greatly increased or decreased by certain conditions, such as nervous temperament, excitement, weather conditions, or other causes which cannot be traced to food or times of milking. One cow gave milk with 5·2 per cent. of fat in April, and with 2·6 per cent. only in May, and there were many other similar cases.

BOARD OF AGRICULTURE REGULATIONS.

According to the Board of Agriculture regulations for milk, when it contains less than 3 per cent. of fat or 8·5 per cent. solids not fat, it is presumed, unless the contrary is proved, that the milk is not genuine. Similarly, separated or skimmed milk must not have less than 9 per cent. of total solids. Since these regulations were made the Board have issued a circular stating that although genuine milk is usually well above the standard it may occasionally, especially in certain seasons of the year, fall below those limits. This points out that the evidence given before the Milk Regulations Committee tended to show that the practice of mixing separated milk with new milk had become more prevalent, especially in the larger towns, and urges local authorities to keep in view the possibility of a milk richer than just up to the standard, having cream abstracted or water or separated milk added to it, and that samples should be taken and submitted for analysis wherever this is suspected.

Regulations necessary.—While the regulations for milk may be objected to because they press hardly in some cases, it is very difficult to suggest how they could be framed otherwise. If the present standards were lowered the fraudulent dairyman would usually have no difficulty in adding a considerable amount of water and separated milk to the genuine article and selling it as such. In this connection it seems to be most desirable that a complete analysis of samples of milk taken by local authorities should always be made. The dairyman who is fraudulent enough to reduce his milk may be shrewd enough to test the quality of this regularly by ascertaining the fat and calculating the solids not fat. A complete analysis will give the public analyst possession of a number of facts which are not likely to be known by the retailer of milk.

The annual report of the Local Government Board for the year ending March 31st, 1903, states that nearly 30,000 samples of milk were taken over the whole country, of which about 11·6 per cent. were under the standard, and that about 8,400 samples were taken in London, of which about 16·5 per cent. were under the standard. There is, therefore, urgent need for regulations to control adulteration.

SUMMARY OF RESULTS.

(1) **When fat may be low.**—The morning's milk of a herd may frequently be under the standard of 3 per cent. of

fat when milking takes place early in the afternoon, to allow of this milk being retailed on the same day. For this the only effective remedy seems to be to milk three times a day, to have the third milking as late in the evening as possible, to refrigerate the latter so as to keep it in the best condition possible over night and to either retail this by itself next morning or mix it with the morning's milk. The morning's milk will be distinctly better in quality although less in quantity if milking is done three times a day.

(2) The Alnwick and other tests show that the *milk of a few cows* may very frequently be under the standard, even when the intervals between milking are nearly even. It is evidently desirable that when a sample is taken from the milk of a few cows, and found to be suspicious, that a prosecution should not be decided on till further investigations are made.

(3) **Appeal to the cow.**—This is not by any means a safe test. When the mixed milk of six cows was tested at Seaton Delaval there were two cases in which the variation in amount of fat was over 1 per cent. in the afternoon's milk within twenty-four hours. The Offerton and Broomhaugh results show that the variations from fortnight to fortnight may be considerable.

(4) **Solids not fat.**—These were under the standard at Broomhaugh during July and August, and were low in the autumn at Newton Rigg. They may, therefore, be under the standard in the autumn, and this might be helped by a number of cows calving at that time, as the Cockle Park tests indicate that these are higher for some time after calving.

(5) **Effects of feeding.**—Although considerable changes have been made in the feeding of the different herds while the tests were in progress, none of these have materially affected the quantity or quality of the milk. An important exception to this, however, was found in the monthly tests for one year at

Newton Rigg. Mr. Lawrence states that when the cows there are on pasture it takes 11 quarts of milk to produce 1 lb of butter, whereas 9 quarts of milk do so when the cows are fed indoors. There is no doubt also that improper or careless feeding upsets the cows, and in consequence interferes with the quantity and quality of the milk. It is probable that feeding experiments on cows from which the production of large amounts of milk are desired will give most useful results. Some time ago a herd of cows, which was producing milk rather poor in fat, was found to be receiving more food than they were likely to be able to assimilate. The food was reduced, and after a short time the milk materially improved. At Seaton Delaval the withdrawal of 70 lb of mangels daily did not reduce the quantity or quality of the milk, but it was found on inquiry that the remainder of the food they were receiving contained sufficient feeding material for the cows. At Broomhaugh the cows each received 5 lb to 8 lb concentrated food daily while on pasture, with the result that the milk was as rich in fat in summer as in winter, instead of being poorer as at Newton Rigg.

(6) **Effects of weather.**—The weather conditions have evidently a very important influence on milk production. This is especially noticeable in the Seaton Delaval results, where cold north and north-east winds have considerably lowered the fat contents of the milk. The milk of one cow at Cockle Park has been reduced in percentage of fat by cold nights in June and by hot days in July. Mr. Wilson has also found at Stockton-on-Tees that severe weather has reduced the amount of fat. It is therefore advisable to guard against exposing cows unduly to either severe or hot weather, and especially to great variations in temperature.

(7) **Milk of nervous cows variable.**—Cows of an excitable and nervous temperament may show considerably greater variations than those of a quiet and docile disposition.

This is illustrated by the results from individual cows at Broomhaugh. The milk of one cow at Broomhaugh, which dropped her milk easily, was also variable.

(8) There are probably numerous hidden causes of considerable variation in the milk of individual cows. When a cow is in season the milk has usually less fat and is less in quantity. It has been noticed in one or two cases that the milk is richer in fat immediately before this time.

(9) **Regularity of feeding and milking.**—These are most important, so as to produce the best results as to quantity and quality of milk. Regularity in the length of time cows are turned out is also important. Feeding and milking are usually rather irregular on Sundays, and this causes great variation in the quantity and quality of the milk.

(10) Greater quantity of milk does not as a rule mean poorer quality, nor the reverse. This is well illustrated by the results of tests of individual cows at Broomhaugh and Offerton.

(11) It is desirable that cows which give poor quality milk should not be retained in a breeding herd, as they are likely to produce poor milkers. The individual cows that have been tested show very wide variations in the quantity and quality of their milk, so that there are ample opportunities for selection.

Experiments on Crops and Stock at Newton Rigg.

By W. T. LAWRENCE.

Manuring of meadow hay.—This experiment has been in progress for eight years. The plots have been manured every three years (1886, 1889, 1902). The results for the last two years are as follow:—

Plot.	Manures per acre.	Weight of hay per acre.	
		1902. (Manured.)	1903. (Not manured.)
		Cwt.	Cwt.
1	No manure	28	29
2	10 tons dung	50	42
3	¾ cwt. nitrate, 3 cwt. basic slag, 1½ cwt. kainit ...	40½	33
4	¾ cwt. sulph. am., 3 cwt. basic slag, 1½ cwt. kainit	42½	31¾
5	¾ cwt. nitrate, 3 cwt. super., 1½ cwt. kainit ...	43¼	38
6	¾ cwt. sulph. am., 3 cwt. super., 1½ cwt. kainit ...	43¼	34

Dung gives the heaviest crops, not only in the first, but especially in the second year after its application. Superphosphate is more effective than kainit, and nitrate of soda is on the whole more effective than sulphate of ammonia.

Potash manures for potatoes.—In 1902, potash as kainit produced 1 ton potatoes more per acre than did potash as sulphate of potash. In 1903, muriate of potash was tested against kainit when the latter produced 5 cwt. more potatoes than the former; 1½ cwt. nitrate, 4 cwt. superphosphate and

4 cwt. kainit produced 5 tons 17 cwt. per acre of potatoes, whereas when 1 cwt. muriate of potash replaced 4 cwt. of kainit the crop was reduced to 5 tons 12 cwt. an acre.

Manures and lime for swedes.—A test of different phosphatic manures has been made on this crop, as well as of the effect on finger-and-toe disease of a dressing of freshly slaked lime applied in the newly opened drills which were immediately covered; this latter being done at the request of the Board of Agriculture. The results were as follow:—

Plot.	Dressings.	Weight of swedes.		No. of diseased roots.
		Tons	Cwt.	
1	12 tons dung	17	2	210
2	12 tons dung and 10 cwt. lime	15	1	156
3	1 cwt. nitrate, 5 cwt. super., 2 cwt. kainit and 10 cwt. lime	12	7	102
4	1 cwt. nitrate, 5 cwt. super. and 2 cwt. kainit ...	13	6	204
5	1 cwt. nitrate, 5 cwt. slag and 2 cwt. kainit ...	11	6	Not counted.
6	1 cwt. nitrate, 1½ cwt. super., 3½ cwt. slag and 2 cwt. kainit	9	18	„ „
7	4 cwt. pure dissolved bones and 2 cwt. kainit ..	9	0	„ „

The crop was only slightly attacked with finger-and-toe, and it will be seen that the lime not only reduced the number of diseased roots, but the weight of the crop as well. Superphosphate has given the best results of the phosphatic manures, although last year the mixture of basic slag and superphosphate was more effective. Dissolved bones have given a very poor return.

Clover seeds from different countries.—The eighteen small plots of clovers, grown for the first year in 1902, were again tested last season. The results till now are as follow:—

No. of Plot.	Variety.	Appearance.		
		1902.	1903.	1904.
	Red Clovers.			
1	English singlecut cowgrass	Excellent	Excellent	Good plant.
2	English giant hybrid	„	Good	Almost gone.
3	Chilian	„	Fair	„ „
4	English red	Good	„	Gone.
5	English cowgrass	„	„	Almost gone.
6	New Zealand	„	Good	Fair plant.
7	Canadian red	Fair	„	Gone.
8	Bohemian	„	Fair	Thin plant.
9	Styrian	„	„	Almost gone.
10	Bavarian	„	„	„ „
11	United States	Poor	Good	Thin plant.
12	Russian	„	Fair	Gone.
	White Clovers.			
1	Friesland	Excellent	Fair	Good plant.
2	German	Good	„	Fair plant.
3	Russian	„	Poor	Almost gone.
4	English white	Fair	Good	Good plant.
5	Dutch white	„	Poor	Fair plant.
6	English giant white	Poor	„	Almost gone.

Among the red clovers the English singlecut cowgrass only has fulfilled its good promise of the first year; while this and the New Zealand red are the only two that are giving good grazing in the year following that in which they were cut for hay. Of the white clovers English and Friesland are best established, while German and Dutch are doing fairly well.

Rotation experiment.—This is in progress, and, when completed, will be fully reported on.

Breeding for fat lambs.—Half-bred ewes (Cheviot Border-Leicester) are usually bought in the autumn for breeding fat lambs, an Oxford Down ram being used. It was decided last autumn to compare the results of using an Oxford Down, a Wensleydale, and a Border-Leicester ram on these ewes. Each ram was put to nineteen ewes on October 3rd, and withdrawn on November 18th. All the ewes lambed between February 28th and March 25th, except one from the Oxford Down lot which was barren, with the following results:—

Down cross ...	... 34 lambs, of which	1 died.
Wensleydale cross	... 34 ,, ,,	3 ,,
Leicester cross ...	... 32 ,, ,,	2 ,,

Of those that died one was a strong single lamb of the Leicester cross; the loss of which somewhat affected the Leicester results. The others were mostly weaklings.

Week by week the most forward fat lambs were weighed, and all that turned 4½ stones in May or 5 stones in later months were sold by auction, the different crosses being sold in separate lots. The results were as follow:—

Date of sale.	Down cross.					Wensleydale cross.					Border Leicester cross.				
	No. of lambs.	Weight.	Price.			No. of lambs.	Weight.	Price.			No. of lambs.	Weight.	Price.		
		lb.	£	s.	d.		lb.	£	s.	d.		lb.	£	s.	d.
May 16	3	192	4	12	3	4	267	6	7	0	3	199	4	13	0
,, 23	4	276	6	7	0	4	274	6	6	0	4	252	6	5	0
,, 30	6	431	8	6	6	3	232	4	8	6	3	203	3	18	0
June 13	6	448	9	7	0	3	228	4	9	3	2	143	3	5	0
,, 24	7	554	10	3	0	4	312	5	15	0	4	317	5	17	0
July 4	3	246	4	16	0	4	331	6	7	0	3	242	4	9	3
,, 18	2	160	3	2	0	6	495	9	9	0	3	233	4	11	6
,, 25	...	...	...			1	82	1	10	0	3	261	4	14	0
Aug. 8	2	162	3	0	0	2	173	2	16	0	5	405	6	17	9
Total	33	2,469	49	13	9	31	2,394	47	5	9	30	2,255	44	11	6

The Down lambs matured most quickly for the market, and therefore had less cost for "keep" than the others. This also allowed the dams of those lambs to be fattened and sold more quickly than the other ewes, thereby realizing better prices and costing less to keep.

The following gives an analysis of the results with the different lots of lambs:—

	Average weight. lb.	Average value.	Average value per lb.
Down cross	74·8	30/1½	4·83d.
Wensleydale cross	77·2	30/6	4·74d.
Border Leicester cross ...	75·2	29/8½	4·74d.

When the earlier maturity of the Down lambs is taken into account, the results with them must be considered the most satisfactory.

The dairy.—The number of dairy cows in the herd is about sixteen, which produce on the average 590 gallons of milk per cow annually. Most of the milk is made into Cheddar cheese, or butter, or cream cheese, but some of it is retailed, or used for calf feeding. For 1903 the gross value of the dairy produce per cow was £15 10s., to which should be added £2 as the value of her calf when born. The returns for cheesemaking last year were slightly over 8d. per gallon of milk, whereas the returns from buttermaking were under 6d. a gallon. The results of the milk investigations at Newton Rigg are given on page 70.

The Durham College of Science,

NEWCASTLE-UPON-TYNE.

Agricultural Department.

PRINCIPAL, SIR ISAMBARD OWEN, M.A., M.D.

Subjects.	**Professors and Lecturers.**
Agriculture, Dairy Farming, Estate Management, Agric. Entomology and Farm Book-keeping.	Professor D. A. Gilchrist, M.Sc., F.R.S.E. C. Bryner Jones, M.R.A.S.E., F.H.A.S. Geo. Potts, B.Sc., Ph.D., N.D.A., F.H.A.S.
Forestry	A. C. Forbes, F.H.A.S.
Chemistry	Professor P. Phillips Bedson, M.A., D.Sc., F.I.C., F.C.S. F. C. Garrett, M.Sc., F.C.S. J. A. Smythe, M.Sc., Ph.D.
Agricultural Chemistry	S. H. Collins, F.I.C., F.C.S.
Botany & Agricultural Botany	Professor M. C. Potter, M.A., F.L.S. M. Brack, B.A., B.Sc.
Geology & Agricultural Geology	Professor G. A. Lebour, M.A., M.Sc., F.G.S.
Natural History ...	Professor G. S. Brady, M.D., LL.D., D.Sc., F.R.S.
Anatomy, Physiology, and Pathology of Farm Animals ...	A. Meek, M.Sc., F.Z.S.
Mathematics	Professor C. M. Jessop, M.A. G. W. Caunt, M.A. W. M. Davidson, M.A., M.Sc.
Physics	Professor H. Stroud, M.A., D.Sc., F.Ph.S.L., M.I.E.E. R. J. Patterson, M.Sc. J. W. Bullerwell, M.Sc.
Engineering and Agricultural Engineering	Professor R. L. Weighton, M.A., M.I.N.A. H. R. Cullen, M.A. W. W. Firth, M.Sc.
Surveying	Professor Henry Louis, M.A., A.R.S.M., F.I.C., F.G.S. G. H. Stanley, A.R.S.M.
Horticulture	John G. Murray.

Secretary—F. H. Pruen.

This list comprises the names of Teachers whose classes are attended by Agricultural Students. A complete List of the Professors and Lecturers will be found in the College Calendar.